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WIDE AREA ILLUMINATOR DEVELOPMENT FOR U.S. COAST GUARD HH-3F HE--ETC(U)
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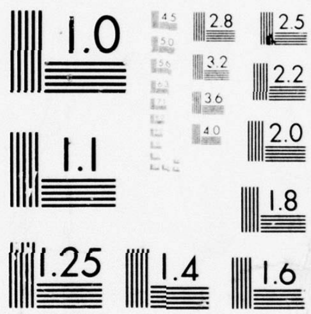

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WIDE AREA ILLUMINATOR DEVELOPMENT FOR U.S. COAST GUARD HH-3F HELICOPTER

FEBRUARY 1977

FINAL REPORT

PREPARED FOR

U.S. DEPARTMENT OF TRANSPORTATION

UNITED STATES COAST GUARD
OFFICE OF RESEARCH AND DEVELOPMENT
WASHINGTON, D.C. 20590

NOTICE

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16. Abstract

A program to define and design a wide area illuminator to be used on the United States Coast Guard HH-3F search and rescue helicopters is described. An explanation of the Night Vision Laboratory computer search model and how it was used to select the optimum light source for the application is given. Finally, the completed purchase description and the test plan for use in evaluating the hardware when developed is presented. It is anticipated that the first of the illuminators will be available for testing on aircraft during 1978.

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METRIC CONVERSION FACTORS

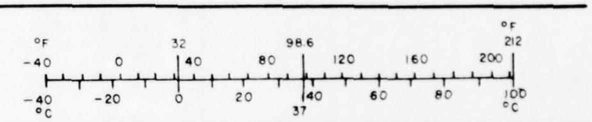
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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WIDE AREA ILLUMINATOR DEVELOPMENT FOR

U.S. COAST GUARD HH-3F HELICOPTER

I. INTRODUCTION As a result of a meeting between personnel from the Office of Research and Development, United States Coast Guard Headquarters, and the Night Vision Laboratory (NVL), the Coast Guard representatives requested a proposal from NVL for the definition and design of a wide area illuminator to be mounted on the HH-3F helicopter to aid in search and rescue operations at night. See Figure 1 for a photograph and description of the HH-3F. A proposal was forwarded to Coast Guard Headquarters in May 1975 that resulted in funding under MIPR Number Z-70099-5-53939 for the following scope of work as stated in the proposal:

TASK I - DEFINITION OF DESIGN REQUIREMENTS

A literature search and systems analysis will be conducted to identify and define the design criteria necessary to visually acquire and identify the objects of helicopter searches conducted at night with light sources. This analysis will include but not be limited to consideration of the following:

a. color contrast requirement

b. illumination levels required

c. problems of backscatter

d. light location and controllability

e. shape and orientation of the beam pattern

f. relationship between object size and illumination level

g. methods of target enhancement

Figure 1. HH-3F U.S. Coast Guard Search and Rescue Helicopter. Built by Sikorsky Aircraft Company to Coast Guard specifications, the HH-3F is powered by two 1,500 horsepower General Electric T-58-5 gas turbine engines. It has a top speed under normal power of 142 knots (163 miles per hour). Its cruising speed is 130 knots or 150 miles per hour. Two auxiliary tanks give the aircraft a fuel capacity of more than 1,100 gallons and a range of nearly 700 miles. It can fly 345 miles out to sea, automatically hover for 20 minutes, pick up six survivors, and return to land. The HH-3F is designed with a cabin space of 20 by 6 by 6 feet, a rear ramp, and a starboard side door equipped with a rescue platform. Sponsons and pop-out flotation bags are provided for rough water landings and pickups. It has an external hoist with 240 foot cable.

h. aircraft safety

i. size of the area to be searched

As a baseline, a man in the water wearing an approved life jacket will be considered the object of the search. He will have no active means of attracting the attention of the helicopter crew except by his physical presence. The helicopter will search at an altitude of 500 feet and at a speed of 75-100 knots. Data on the reflectivity of typical life jackets, Coast Guard Search methods, HH-3F configuration and limitations, as well as the results of previous Coast Guard work related to this effort will be provided by the Coast Guard at the beginning of the program. NVL has established a computer search program and believes this program will be useful in obtaining results for this program.

TASK II - DETERMINATION OF LIGHT SOURCE

Based on the results of Task I, a detailed survey of available light sources will be conducted. Comparisons between the existing light sources will be made to determine the one which best meets the technical characteristics defined in Task I. Modifications which can be made to existing light sources will be considered in the selection of the best approach. Choice of the light source will be based in part on the following limitations provided by the Coast Guard:

a. 250 pound weight limit

b. HH-3F aircraft interface limitations

c. 12 KVA of 115/200 volt, 3 phase 400 HZ power.

TASK III - PREPARATION OF TECHNICAL SPECIFICATION

Prepare detailed design and performance specifications suitable for competitive procurement for a prototype lighting system based on the

results of Task II. Prepare a cost estimate for the proposed procurement.

TASK IV - PREPARATION OF TEST PLAN

Prepare a detailed Test Plan (TP) for testing and evaluation of the prototype light system. This TP will cover both laboratory and field evaluations. The TP will include but not be limited to the requirements for test equipment, test sites, and methods of collecting and analyzing the data. Close coordination with the Coast Guard will be required with respect to available facilities and Coast Guard test philosophy.

TASK V - PROGRAM MANAGEMENT AND PREPARATION OF FINAL REPORT

The program management effort will provide for close coordination between the Night Vision Laboratory and the U.S. Coast Guard as well as coordination between the various elements within the Night Vision Laboratory. This program management effort will also include a monthly progress report.
A draft final report covering the work accomplished under Tasks I thru IV will be prepared and submitted for U.S. Coast Guard review. After appropriate review by U.S. Coast Guard, the final report will be completed.
There are four deliverable items required under this MIPR. They are as follows:

1. monthly progress reports
2. purchase description for the illuminator
3. test plan for the illuminator hardware
4. final report

Section II of this report describes the development of the search model for the Coast Guard application. Section III covers application of the search model to the particular problem using the constraints and objectives as inputs. From a list of five prime candidate light sources, one is then selected as the preferred source using the probabilities of detection for each gained from the model output. General conclusions are discussed in Section IV partially in terms of the planned continuation of the effort for the hardware to be developed and tested. Appendix A is the Fortran code for the search model, Appendix B is the purchase description including laboratory test requirements and finally Appendix C is the test plan for the illuminator when mounted on the HH-3F.

II. SEARCH MODEL An eyeball lobe search model has been developed at NVL and it is this model that was adapted for the Coast Guard application and applied to the situation of night search at sea with a floodlight system. The search process of the eye in an unstructured field such as the sky or a relatively calm sea has been modelled as a random process utilizing a detection lobe concept. A detection lobe is defined as a circular area about the center of fixation of the eye within which detection is defined to be 100 percent and outside 0 percent. A lobe is a function of the light level presented to the eye and the target parameters of angular size and brightness contrast. The detection lobe has been measured for many different target sizes and contrasts, however there is little data on the performance of off-axis vision at varying light levels. This model predicts

both on and off-axis vision for all conditions based on the known physiology of the eye. Additionally a discussion of the treatment of backscatter from a wide area illuminator is included.

BASIC MODEL The probability of acquiring a target in time t for an unstructured field can be given by an equation of the form:

$$P(t) = P_I(1-e^{-at}) \tag{1}$$

Here P_I is the probability that the target will ever be detected. In the limiting case of an unstructured field this will be the probability that if the observer fixates the target foveally he will detect it, times the probability that he will fixate the target. The term a in the exponential is the value that describes the search performance since it will determine how quickly the curve will rise. The form for a is:

$$a = \frac{A_E}{A_S\ t_g} \tag{2}$$

where A_E is the area of the eyeball lobe for the target and light level, A_S is the search area to be investigated and t_g is the fixation time for the eye taken to be .3 seconds. The implied assumptions here are that the eye lobe is sufficiently small with respect to the search area such that there is little wasted search on the perimeter of the search field, and that the time between fixations is sufficiently small with respect to t_g that it may be ignored.

VALIDATION The success of this technique will depend on how well one models the eyeball lobes. Figure 2 shows the agreement of this model prediction with measured lobes of Erickson and Burge.[1] The light level dependence of the lobes is attributed to increased sensitivity in the periphery for low light levels. This effect of light level on the lobes is shown in Figures 3 and 4. To validate equation (2) as a viable method for a zero clutter search model we went to an experiment performed by Smith and Davies of the Royal Aircraft Establishment (RAE). This experiment was for an observer to detect an aircraft approaching in a clear sky. This situation was simulated with imagery projected on a wide screen. Figure 5 shows the agreement of the model predictions with results of the RAE experiment for different simulated weather conditions.

APPLICATION TO COAST GUARD SEARCH AND RESCUE The Coast Guard is interested in continuously improving its capability for search and rescue at night. To effect an improvement, a request was made of NVL for assistance in the design and selection of a wide area illuminator for helicopter search and rescue. As a consequence, a computer code was developed around the search model described previously. In order to do a design tradeoff analysis one must consider the parameters of the illuminator,

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1. "Air-to-Ground Visual Acquisition of Tactical Targets" Ronald A. Erickson, AD246315

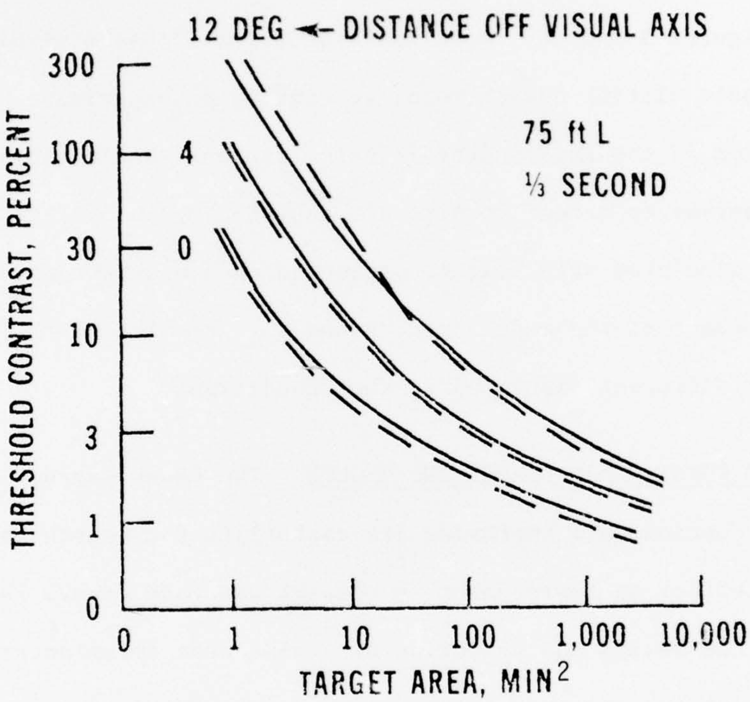


Figure 2. Circular Target Detection (Erickson and Burge)

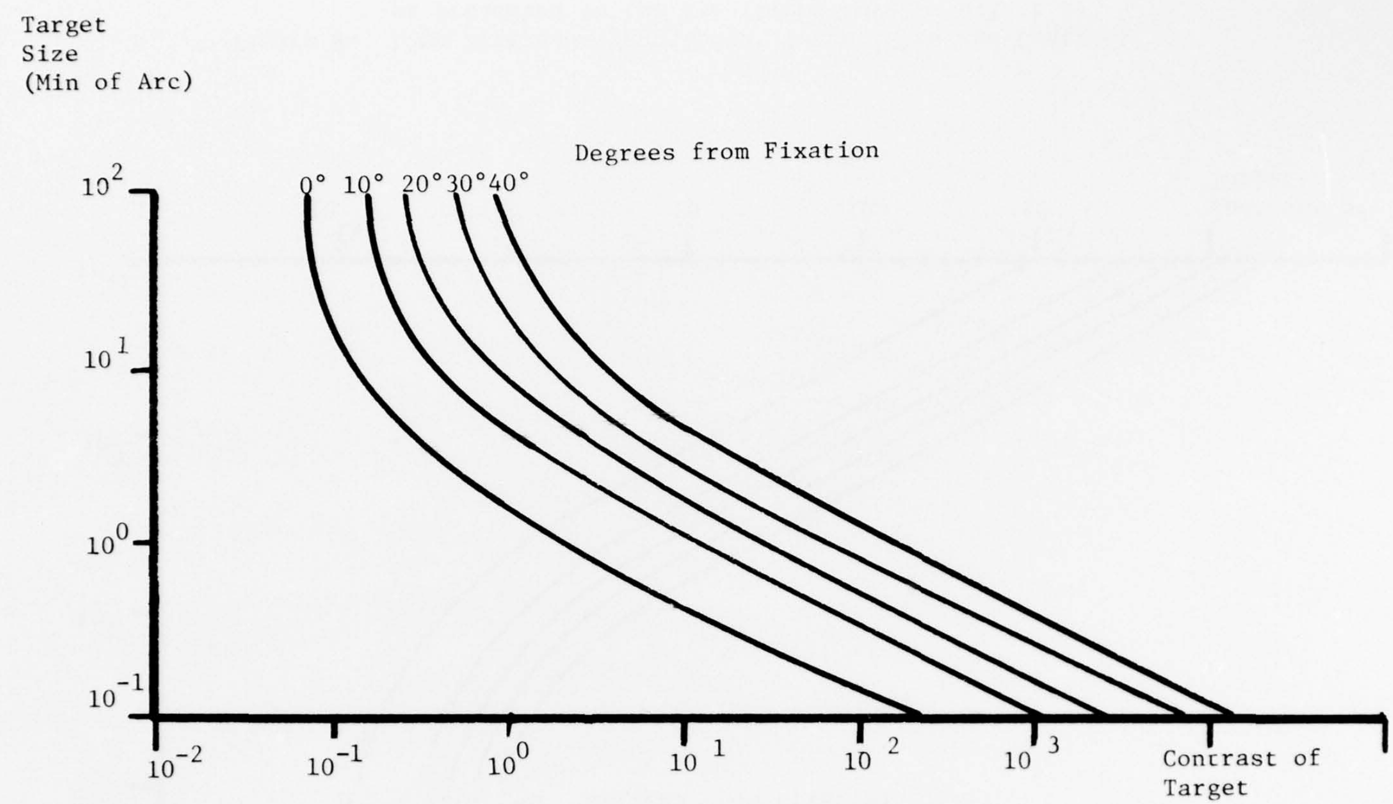


Figure 3. Lobe Size as a Function of Target Size and Contrast as Presented to the Eye (Light Level = 1.5 ft L)

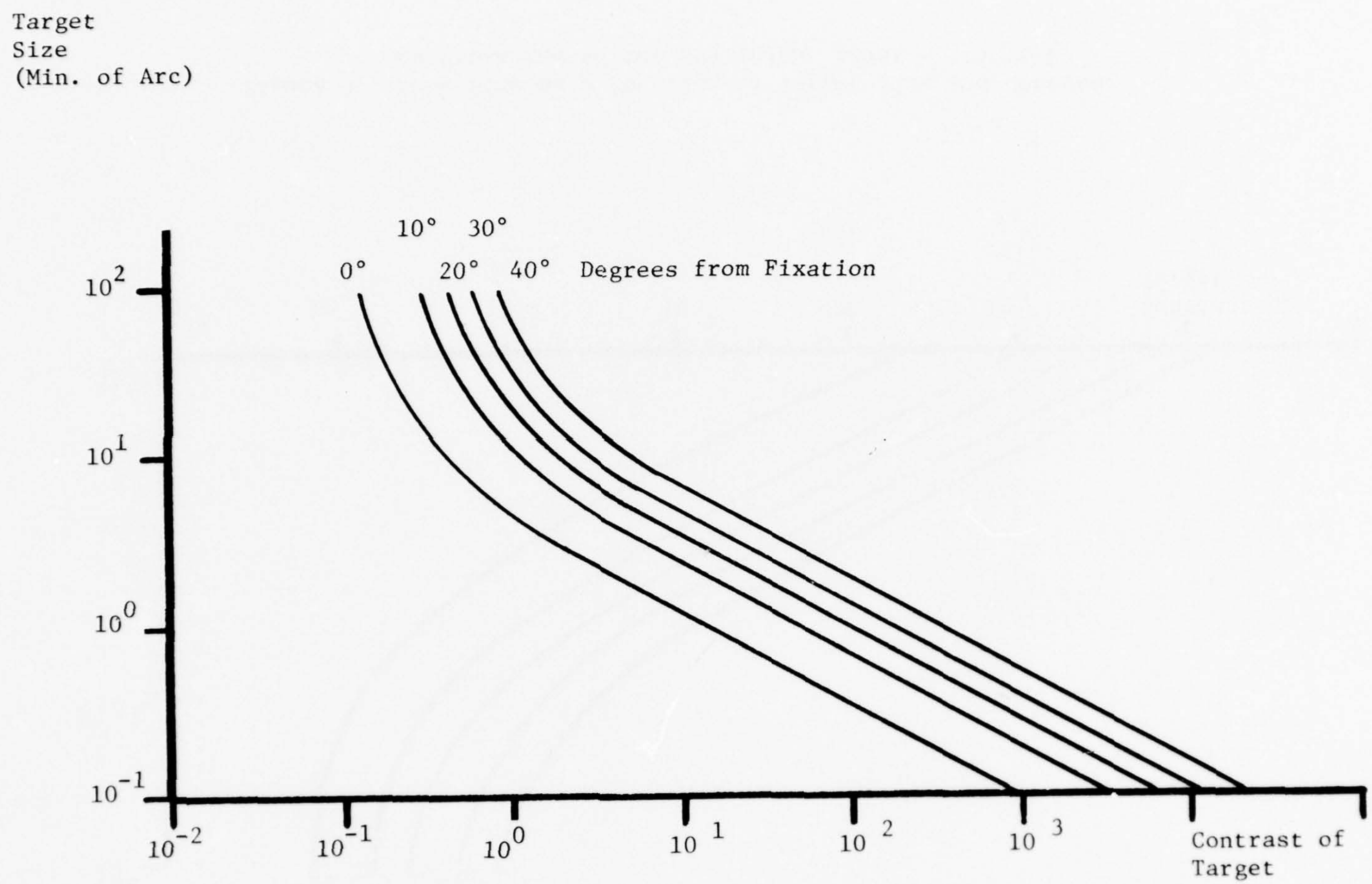


Figure 4. Lobe Size as a Function of Target Size and Contrast as Presented to the Eye (Light Level = 0.1 ft L)

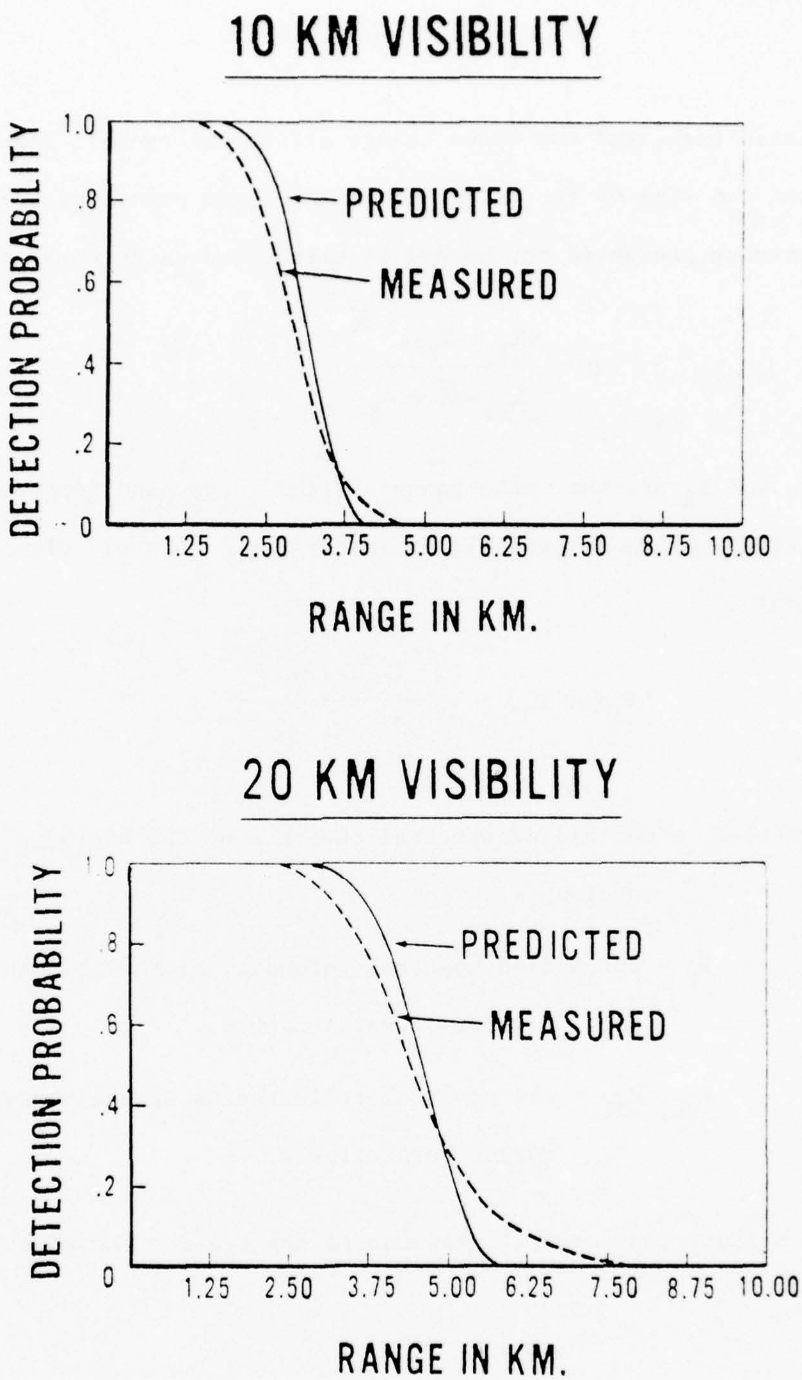


Figure 5. Predicted vs Experimental Detection Ranges
Approaching Aircraft Simulation
(Davies & Smith, RAE)

the search task, and how these things affect the eyeball lobe (i.e., contrast and size of the target and light level presented to the eye). the contrast presented to the eye is calculated using the formula:

$$C = \frac{(R_T - R_B)e^{-G\overline{R}}}{R_{Be}{}^{-\sigma\overline{R}} + B_S} \tag{3}$$

Here R_T and R_B are the reflectances of the target and background respectively which are calculated spectrally. They are given by the equation:

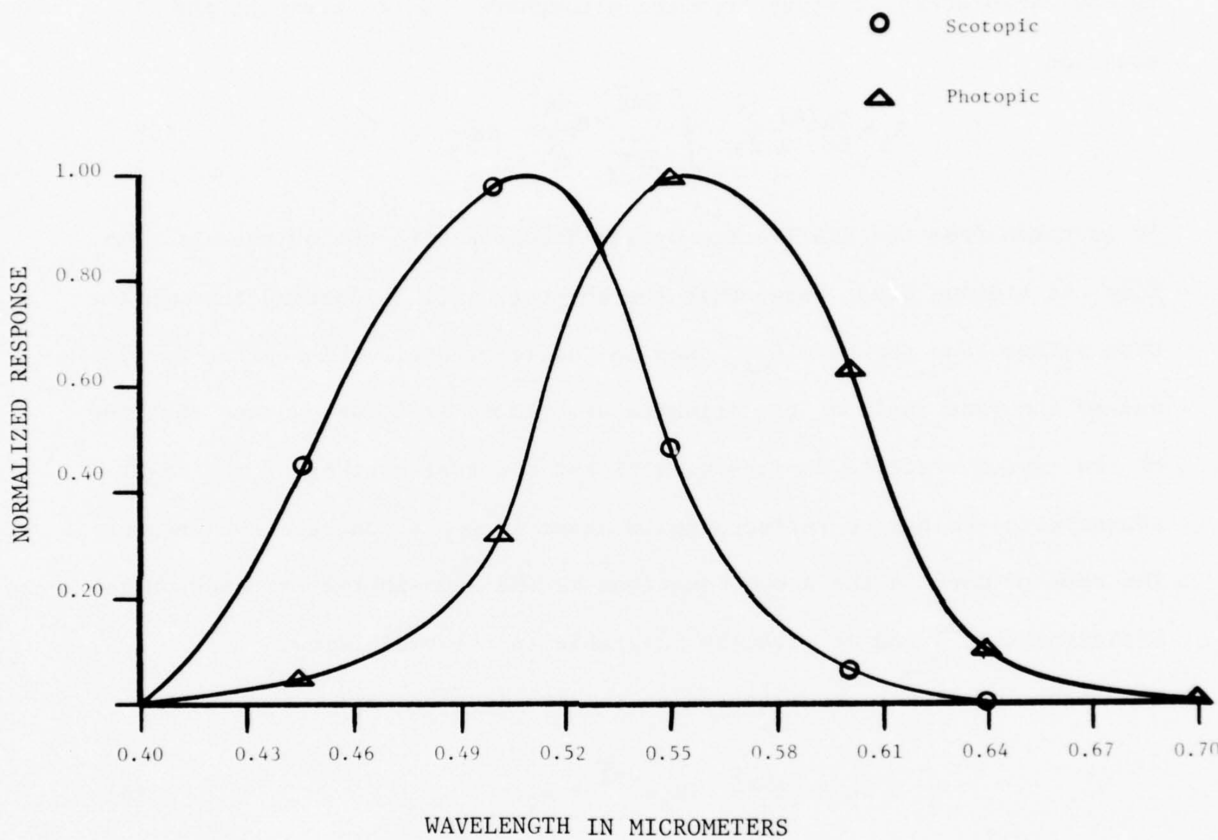
$$R_B(\text{or } R_T) = \frac{\int V_L\ I_L\ P_{BL}\ dL}{\int V_L\ I_L\ dL} \tag{4}$$

where V_L = normalized spectral response of the eye as a function of wavelength L.

I_L = normalized spectral intensity of the illuminator source as a function of wavelength L.

P_{BL}, P_{TL} = the spectral reflectances of the background or target respectively.

Figure 6 shows the spectral response of the eye for the photopic (daylight)



WAVELENGTH IN MICROMETERS

Figure 6. Relative Spectral Response of the Eye

and the scotopic (night) light levels. These curves are shifted as a function of the light level.

The term B_s is the term which accounts for the contrast attenuation due to the backscatter of light from the atmosphere. B_s is given by the equation:

$$B_S = \frac{0.24I\ \sigma^2}{685 \times 2\pi} \int_{2\sigma R_1}^{2\pi\bar{R}} \frac{e^{-x^2}}{x^2}\ dx \qquad (5)$$

It is taken from the RCA Electro-Optics Handbook with the adjustment that R be the average slant range that the observer will be looking through the beam rather than the term R_{max} used in the reference. This correction is due to the wide angle of the illuminator. Immediately we can see that one of the system tradeoff designs will be the spectral content of the light source with the target reflectance in order to get a contrast enhancement. The term σ used in the above equations is the atmospheric attenuation coefficient (km^{-1}) and is directly relatable to the visibility.

The light level that is presented to the eye is given as:

$$LL = \frac{3.42I}{\pi\ A_B}\ (R_B e^{-\sigma\bar{R}} + B_S) \qquad (6)$$

where A_B is the area of the beam of light as it is projected on the water. The light is assumed to be projected in such a way that the illumination level is approximately uniform across this area. This would be an optimum design for uniform search. In addition, several other parameters must be dealt with when Coast Guard search patterns are being considered. These are aircraft

velocity (v), altitude (h), radius (r) of the beam on the water and azimuthal angle (θ) of the beam on the water. A decrease in altitude of the aircraft increases the angular target size as subtended at the observer and therefore increases probability of detection (POD) of the target, but decreases flight safety. Also, the illuminator beam radius presents a tradeoff between track spacing for a search pattern and light level such that if the radius is increased, the light level will decrease resulting in a decreased POD. The aircraft velocity and the azimuthal angle will affect the amount of time that the target will appear in the beam and thus the amount of time the observer will have to search for the target. A further tradeoff is that if the azimuthal angle is decreased not only is the time in the beam reduced (tending to decrease POD) but the light level will increase, which has a tendency to counterbalance the effect of decreased time in the beam. The time in the beam and the angular target size are calculated as average values. This distance is given in terms of the altitude above the water h and the radius of the beam pattern r by:

$$\bar{R} = 0.5 \left[\sqrt{r^2 + h^2} + \frac{K^2}{r} \ell n \left(\frac{r}{h} + \frac{\sqrt{r^2 + h^2}}{h} \right) \right] \qquad (7)$$

<u>USERS GUIDE AND DOCUMENTATION</u> The computer code for this program is in FORTRAN and should meet ANSI standards and be executable on any standard FORTRAN compiler. The basic execution deck for this program consists of 9 cards. There is a capability to run the calculations more than once (multiple runs) so one may perform several tradeoffs in one execution of the program.

Table 1 lists the input cards by their identifier and then a list and the description of the variables that follow. The first card for an execution deck will be a FOR 1 card. This card will then be followed with the other input cards if additional calculations (multiple runs) are to be made. The first set of cards should be followed with an ENDS card. The last card on the last multiple run must be a DONE card. Figure 7 shows sample computer cards. The complete FORTRAN code used for the search model is presented in Appendix A. It is included so that it will be available to Coast Guard personnel in working future SAR problems.

TABLE 1

List of Input Cards by Identifier and Description of the Variables That Follow

IDENTIFIER (COL. 1-4)	Field	Variable	DESCRIPTION
LITG	1	BRITE	Lumens of light from the source in units of 10^5 lumens
	2	HITE	Altitude of aircraft above water in km
	3	RADI	Radius of beam in km
	4	EFF	Efficiency of reflector as a decimal
	5	VEL	Velocity of aircraft in knots
	6	ANGLE	Azimuthal angle of beam pattern in 10^2 degrees
	7	XSIZE	Target dimension in the x direction in meters
	8	YSIZE	Target dimension in the y direction in meters
	9	SIG	Atmospheric visibility in km
	10	D	Distance of observer from light source in meters
SLGT	Card 1 2-15 Card 2 16-31	SL(1) - SL(15) SL(16) - SL(31)	The search light relative spectral intensity at every .01 micrometer interval starting at .4 micrometer.
TARG	Card 1 2-16 Card 2 16-31	TG(1) - TG(15) TG(16) - TG(31)	The spectral reflectance of the target at every .01 micron interval starting at .4 micrometer.
BACK	Card 1 2-16 Card 2 16-31	BK(1) - BK(15) BK(16) - BK(31)	The spectral reflectance of the background at every .01 micrometer interval starting at .4 micrometer.
FOR1	--	--	Beginning Control Card
ENDS	--	--	Control card at end of a multiple run
DONE	--	--	Control card at the end of job

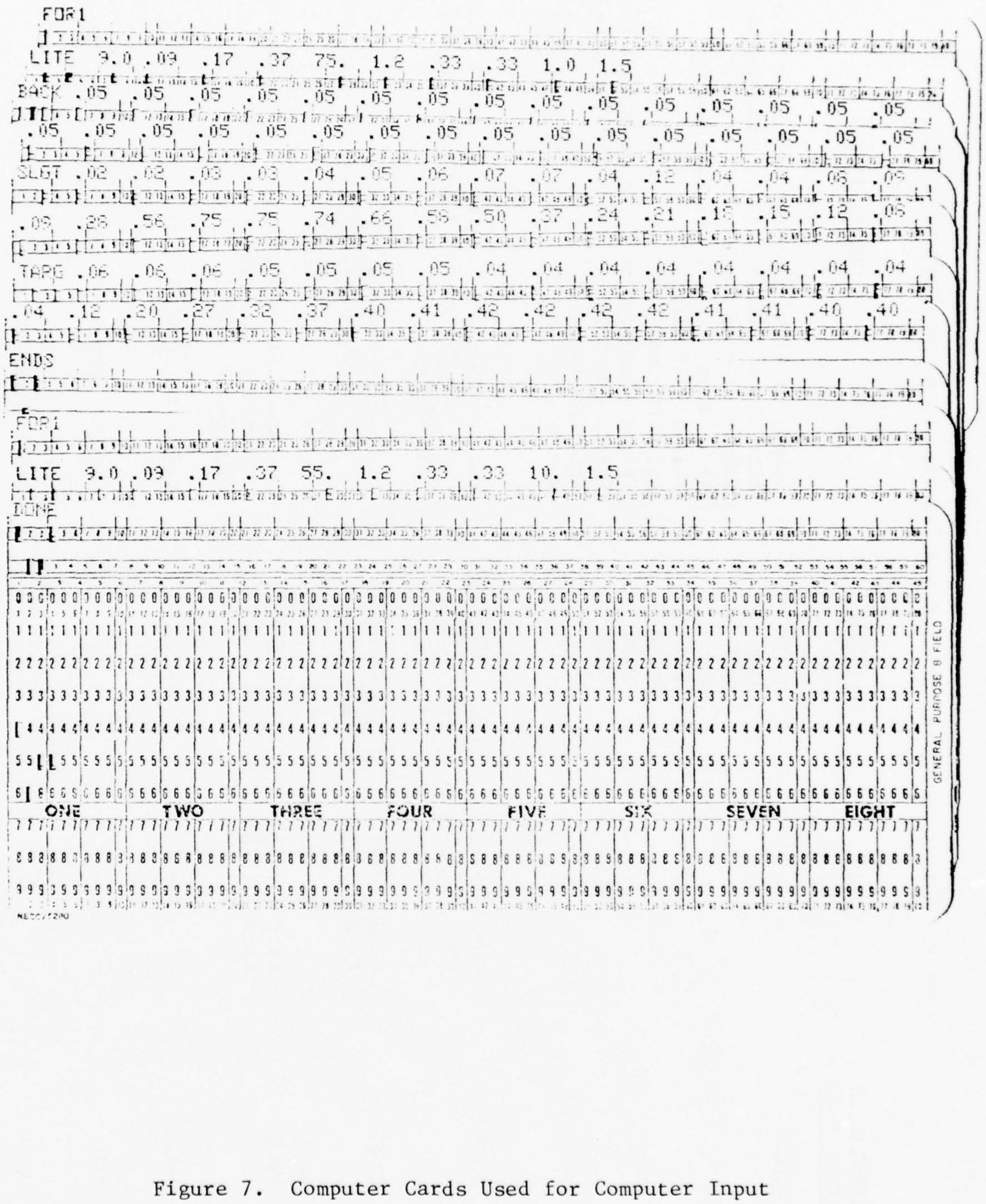


Figure 7. Computer Cards Used for Computer Input

III. APPLICATION OF SEARCH PROGRAM Here the input variables of the search program are each defined and presented. The program outputs are tabulated in terms of the probability of detection for each candidate light source being considered using a typical set of search conditions and for both a man in the water target and a sixteen foot fiberglass boat. Following selection of the optimum light source, two separate sets of data are obtained; one set is for a helicopter velocity of 75 knots and the other for a velocity of 100 knots. POD's are output for eight separate beam radii in the water, for man in the water and boat target, and two separate azimuthal light beam angles on the water for each of the helicopter velocities. From this table of results given for the various operating conditions the Coast Guard Headquarters personnel were able to select the desired azimuthal angle of the beam on the water on each side of the helicopter and radius of the beam pattern on the water for the actual hardware to be developed. The selected values appear in the specification for the illuminator that is presented as Appendix B.

PROGRAM VARIABLES. The computer program requires that values be input for the following variables:

1. Total visible flux produced by the light sources.
2. Efficiency of the reflectors (includes collection and reflection efficiencies).
3. Spectral distribution of the light sources.
4. Spectral reflectance of the background.
5. Spectral reflectance of the target.
6. Dimensions of the target.
7. Velocity of the helicopter.

8. Altitude of the helicopter.

9. Radius of the beam pattern on the water.

10. Azimuthal angle of the beam pattern on the water on each side of the helicopter.

11. Atmospheric visibility.

12. Separation distance between observer and luminaires.

The output values from the program include the calculated target contrast, the average angular subtense of the target with respect to the observer, the light level presented to the eye of the observer, the detection lobe angle and the probability of target detection. The probability of detection (POD) is the key output parameter.

DETERMINATION OF VARIABLE VALUES. A discussion of each of the variables listed above is given in numerical order:

1. The visible flux is dependent upon the available power, the choice of light source and efficiency of the driving circuitry. Based on the guidelines and constraints set forth for this effort by the Coast Guard, the available power on the HH-3F helicopter for this system is 10 kilowatts. Five candidate light sources were investigated for this application. These were:

a. High pressure sodium arc

b. Metal halide arc

c. Clear mercury arc

d. Xenon short arc

e. Quartz iodine incandescent

Other types of sources were excluded for various reasons including low efficiency, low intensity and large source size.

The total visible flux for each of the candidate light sources is listed in Table 2. The data for source luminous efficacy and ballast efficiency

TABLE 2

Characteristics of the Five Candidate Light Sources

Lamp Type	Initial Luminous Efficacy in Lumens/Watt	Typical Ballast Efficiency	Total Flux in Lumens	Typical Reflector Efficiency
High Pressure Sodium	140	0.90	12.6×10^5	0.50
Metal Halide Arc	100	0.90	9.0×10^5	0.50
Clear Mercury Arc	63	0.90	5.7×10^5	0.50
Xenon Short Arc	35	0.70 (Resistor)	2.4×10^5	0.70
Quartz Iodine Incandescent	26	1.00 (No ballast)	2.6×10^5	1.00 (Sealed beam)

were obtained from the latest commercial literature. Total flux from the lamps is obtained by multiplying total system power (10,000 watts) times ballast efficiency times source luminous efficacy. Final selection of the optimum source was made based upon examination of performance as detailed in the analysis paragraph of this section.

2. The reflector efficiencies listed in Table 2 are typical for the sources listed.

3. Normalized spectral distributions for each of the five candidate sources are shown in Table 3.

4. A typical seawater spectral reflectance curve was used for the background spectral reflectance and Table 4 consists of a numerical listing of these spectral reflectance values.

5. The "worst case" target originally investigated was a man in the water with an orange lifejacket. To determine the spectral reflectance of a typical lifejacket, a number of red and orange lifejackets in both adult and child sizes were analyzed with a spectrophotometer. It was decided that the orange lifejackets were the most typical and therefore, the orange lifejacket with the lowest spectral reflectance curve was chosen as the worst case. A numerical listing of its reflectance values is included in Table 4.

Following analysis of the man in the water situation and review of the results by Coast Guard Headquarters personnel, it was decided that the area of coverage by the illumination system to achieve a reasonably high POD was too small. Therefore, Coast Guard personnel requested that the target type be modified to include a 16 foot boat also.

To determine the spectral reflectance of a typical boat, a number of paints

TABLE 3

Normalized Spectral Distributions of

Light Sources

(In micrometers)	Sodium Vapor	Metal Halide	Clear Mercury	Xenon Short Arc	Quartz Iodine Incandescent
0.40	0.03	0.29	0.52	0.70	0.12
0.41	0.04	0.29	0.52	0.80	0.14
0.42	0.05	0.13	0.07	0.64	0.16
0.43	0.07	0.15	0.95	0.75	0.18
0.44	0.08	0.15	0.95	1.00	0.20
0.45	0.08	0.05	0.10	0.84	0.22
0.46	0.09	0.08	0.05	0.90	0.25
0.47	0.09	0.19	0.04	0.92	0.28
0.48	0.05	0.19	0.05	0.86	0.31
0.49	0.15	0.10	0.05	0.84	0.34
0.50	0.15	0.28	0.05	0.81	0.37
0.51	0.07	0.28	0.04	0.81	0.40
0.52	0.06	0.09	0.05	0.81	0.43
0.53	0.04	0.15	0.05	0.81	0.47
0.54	0.05	0.30	1.00	0.81	0.50
0.55	0.11	0.30	1.00	0.80	0.53
0.56	0.47	0.28	0.17	0.79	0.56
0.57	0.52	0.29	0.95	0.79	0.59
0.58	0.65	0.53	0.95	0.79	0.63
0.59	0.80	0.69	0.44	0.79	0.67
0.60	0.80	0.69	0.05	0.78	0.70
0.61	0.59	0.20	0.05	0.76	0.73
0.62	0.48	0.22	0.06	0.77	0.76
0.63	0.20	0.22	0.07	0.77	0.80
0.64	0.16	0.12	0.06	0.75	0.83
0.65	0.12	0.07	0.04	0.74	0.87
0.66	0.11	0.10	0.04	0.74	0.89
0.67	0.09	0.10	0.03	0.72	0.92
0.68	0.08	0.10	0.02	0.72	0.95
0.69	0.07	0.07	0.00	0.76	0.98
0.70	0.06	0.05	0.00	0.71	1.00

TABLE 4

Spectral Reflectances

(In micrometers)	Seawater (Background)	Orange Lifejacket	White Fiberglass
0.40	0.02	0.02	0.47
0.41	0.02	0.02	0.61
0.42	0.02	0.02	0.66
0.43	0.02	0.02	0.69
0.44	0.02	0.02	0.72
0.45	0.02	0.02	0.73
0.46	0.02	0.02	0.74
0.47	0.02	0.02	0.75
0.48	0.02	0.02	0.76
0.49	0.02	0.02	0.77
0.50	0.02	0.03	0.78
0.51	0.02	0.03	0.80
0.52	0.02	0.03	0.81
0.53	0.02	0.03	0.83
0.54	0.02	0.04	0.85
0.55	0.03	0.05	0.86
0.56	0.03	0.09	0.87
0.57	0.03	0.14	0.89
0.58	0.03	0.22	0.89
0.59	0.03	0.30	0.90
0.60	0.03	0.34	0.90
0.61	0.03	0.37	0.90
0.62	0.03	0.37	0.90
0.63	0.03	0.38	0.91
0.64	0.03	0.38	0.91
0.65	0.04	0.38	0.91
0.66	0.04	0.39	0.91
0.67	0.04	0.39	0.91
0.68	0.04	0.39	0.92
0.69	0.04	0.40	0.92
0.70	0.04	0.40	0.92

and fiberglass materials were obtained and analyzed. It was decided by Coast Guard personnel that white fiberglass would be used as the typical boat finish. A listing of the reflectance values for white fiberglass boat material is included in Table 4.

6. For the man in the water situation, the target size had been assumed to be 0.3m. For the case of the 16 foot boat, the target dimensions were assumed to be 5m x 2m.

7. Based upon conversations with Coast Guard pilots, the helicopter velocity was assumed to be between 50 and 100 knots with 75 knots being typical.

8. Altitude of the helicopter was assumed to be 0.15 kilometer (approximately 500 feet). Based upon conversations with Coast Guard pilots and observers, it was assumed that a lower altitude would not be considered safe and higher altitude would decrease detection probability.

9. The lateral throw of the beam pattern was varied from values as low as .01 km to .80 km (1/2 mile) during the analyses. Final design lateral throw was determined as a tradeoff versus POD.

10. Azimuthal angle of the beam pattern was assumed to be between 90 and 120 degrees on each side of the helicopter. This was based upon conversations with Coast Guard SAR crew members with regard to viewing angle from the observation positions on the helicopter. Computer runs were also made for lesser angles but this does not result in a higher POD since the advantage obtained by concentrating the light in a smaller angle is offset by the lower period of time that the target is within the illuminated area. Substantial reduction of the azimuthal angle also would present a problem in reflector design for use with the elongated commercial arc sources since a very large reflector would be required to concentrate the light in a narrow beam in the plane of the lamp axis.

11. Original runs were made assuming atmospheric transmission of 4 km. This value was upgraded to 8 km (5 miles) for later runs based upon inputs from Coast Guard personnel.

12. The separation distance between the observer and the luminaires was assumed to be approximately 2m based upon a luminaire mounting location underneath the helicopter. Computer runs were made varying this parameter to the maximum dimensions of the helicopter and no change in POD was obtained using the 8 km atmospheric visibility figure and large beam radius. This is because the amount of backscatter radiation between the observer and the target remains almost constant under these conditions.

ANALYSIS. Computer runs were made to determine which candidate light source yields the best POD for a typical set of conditions. A sample computer output is shown as Figure 8 for the sodium source. Results using the final version of the computer program are listed below.

For the man in the water case with lateral beam throw 0.2 km, helicopter velocity 75 knots and azimuthal angle 90 degrees, the following probabilities are obtained:

Source	POD
Sodium	0.51
Metal Halide	0.43
Clear Mercury	0.29
Xenon Short Arc	0.31
Quartz Iodine	0.40

For the white fiberglass boat case with lateral beam throw of 0.8 km, helicopter velocity 75 knots and azimuthal angle 90 degrees, the following probabilities are obtained:

```
THIS PROGRAM WILL GIVE PROBABILITY OF DETECTION VS.

TIME FOR VISUAL SEARCH WITH A SEARCH LIGHT


SEARCH LIGHT PARAMETERS

TOTAL FLUX OF SEARCHLIGHT          12.[illegible]0   *10**5 LUMENS
RADIUS OF BEAM PATTERN ON H2O      .[illegible]0     KM.
ANGLE OF BEAM PATTERN ON H2O       [illegible]0.00   DEGREES
ATMOSPHERIC VISIBILITY              8.00    KM.
DISTANCE OF OBSERVER TO LIGHT       2.00    METERS
REFLECTOR EFFICIENCY                .50
```

NORMALIZED SPECTRAL INTENSITY OF SEARCHLIGHT

MICRON	.0	.01	.02	.03	.0[illegible]	.[illegible]5	.06	.07	.08	.09
0.4	.03	.04	.05	.07	.0[illegible]	.[illegible]8	.09	.09	.05	.15
0.5	.15	.07	.06	.[illegible]4	.0[illegible]	.11	.47	.52	.65	.80
0.6	.80	.59	.48	.20	.1[illegible]	.12	.11	.09	.08	.07
0.7	.06									

```
HELICOPTER PARAMETERS

VELOCITY OF THE HELICOPTER        7[illegible].[illegible]0   KNOTS
ALTITUDE OF THE HELICOPTER        .[illegible]5     KM.


TARGET-BACKGROUND PARAMETERS

LENGTH OF TARGET                  [illegible].[illegible]0   METERS
WIDTH OF TARGET                   2.[illegible]0    METERS
```

Figure 8. Sample Computer Run for Sodium Source

SPECTRAL REFLECTANCE OF THE TARGET

MICRON	.0	.01	.02	.03	[illegible]	.05	.06	.07	.08	.09
0.4	.47	.61	.66	.69	[illegible]	.73	.74	.75	.76	.77
0.5	.78	.80	.81	.83	[illegible]	.86	.87	.89	.89	.90
0.6	.90	.90	.90	.91	[illegible]	.91	.91	.91	.92	.92
0.7	.92									

SPECTRAL REFLECTANCE OF THE BACKGROUND

MICRON	.0	.01	.02	.03	[illegible]	.05	.06	.07	.08	.09
0.4	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02
0.5	.02	.02	.02	.02	.02	.03	.03	.03	.03	.03
0.6	.03	.03	.03	.03	[illegible]	.04	.04	.04	.04	.04
0.7	.04									

CALCULATED TARGET AND LIGHT LEVEL PARAMETERS

TARGET CONTRAST 3[illegible].10
ANGULAR TARGET SIZE I[illegible] X [illegible] 11.35 MRAD.
ANGULAR TARGET SIZE I[illegible] Y [illegible] [illegible].54 MRAD.
LIGHT LEVEL PRESENTED TO THE EYE .219E-02FT. LAMB.
DETECTION LOBE SIZE 19.69 DEGREES

PROBABILITY OF DETECTION VS. TIME

TIME TARGET WAS IN BEAM	PROBABILITY OF DETECTION
16.27	.58

Figure 8. (cont.)

Source	POD
Sodium	0.58
Metal Halide	0.60
Clear Mercury	0.58
Xenon Short Arc	0.58
Quartz Iodine	0.59

The sodium vapor source was chosen as the best overall source due to its good performance for both the white fiberglass boat and the man in the water case. Computer runs were made for both the man in the water case and the white fiberglass boat with lateral beam throw varied from 0.1 to 0.8 km for azimuthal angles of 90° and 120° and helicopter velocities of 75 and 100 knots. Results are listed in Table 5. Table 5 represents the critical data output for the overall program effort at NVL. From the POD's shown in the table, a beam pattern radius variable in steps of 0.2, 0.4, 0.6, and 0.8 kilometers by preflight adjustment was selected by the Coast Guard as was an azimuthal angle to be set between 90° and 120° - preferably toward the higher angle. These specifications appear in the illuminator purchase description, Appendix B.

TABLE 5

Probabilities of Detection

HELICOPTER VELOCITY - 75 KNOTS

	Man in Water		16' White Fiberglass Boat	
	90° Az.	120° Az.	90° Az.	120° Az.
0.8	*	*	.58	.58
0.7	*	*	.89	.69
0.6	*	*	.98	.96
0.5	.04	*	1.00	1.00
0.4	.11	.09	1.00	1.00
0.3	.24	.21	1.00	1.00
0.2	.51	.47	1.00	1.00
0.1	.90	.89	1.00	1.00

HELICOPTER VELOCITY - 100 KNOTS

	Man in Water		16' White Fiberglass Boat	
	90° Az.	120° Az.	90° Az.	120° Az.
0.8	*	*	.48	.47
0.7	*	*	.80	.58
0.6	*	*	.94	.90
0.5	.03	*	1.00	.99
0.4	.08	.07	1.00	1.00
0.3	.18	.16	1.00	1.00
0.2	.41	.38	1.00	1.00
0.1	.82	.81	1.00	1.00

---

* No lobe size exists.

IV. DISCUSSION With the selection of the beam radius on the surface and the azimuthal angle of the beam and having already selected the light source type, the purchase description could then be completed and is presented as Appendix B. In addition, the test plan for the hardware for testing both at the contractor's plant and after it has been mounted on the HH-3F is completed and enclosed as Appendix C. Two banks of pod mounted luminaires have been specified that comprise the illuminator. Figure 9 is a sketch of the proposed mounting position for the illuminator on the aircraft showing both pods and the support structure between them. Figure 10 shows the exact beam pattern on the water as seen from the aircraft when flying at an altitude fo 500 feet. As the azimuthal beam angle is varied, the different hyperbolic geometrical beam patterns are illustrated with corresponding beam spread distances as a function of the beam radius. Beam coverage from the helicopter at an altitude of 500 feet is shown in the sketch of figure 11 to portray the beam spread from either a single bank of luminaires or with both. Thus the Phase I portion of the development program is concluded with the data given in Table 5 and Figure 10 as well as the Purchase Description and Test Plan. Night Vision Laboratory personnel will continue to act as the technical agents for the U.S. Coast Guard during the Phase II hardware portion of the program that will include contractor fabrication, test and evaluation of the high pressure sodium wide area illuminator.

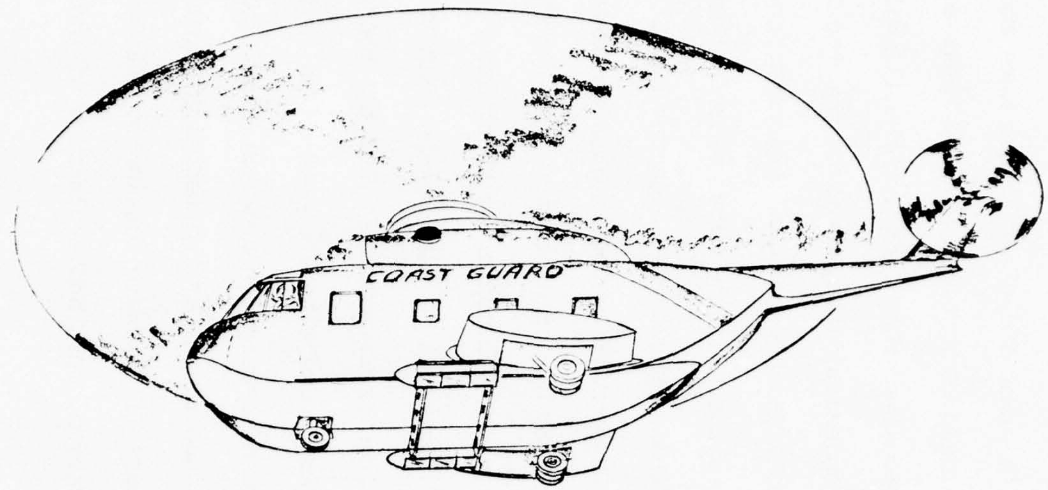


Figure 9. Mounting of Illuminator Pods on Helicopter

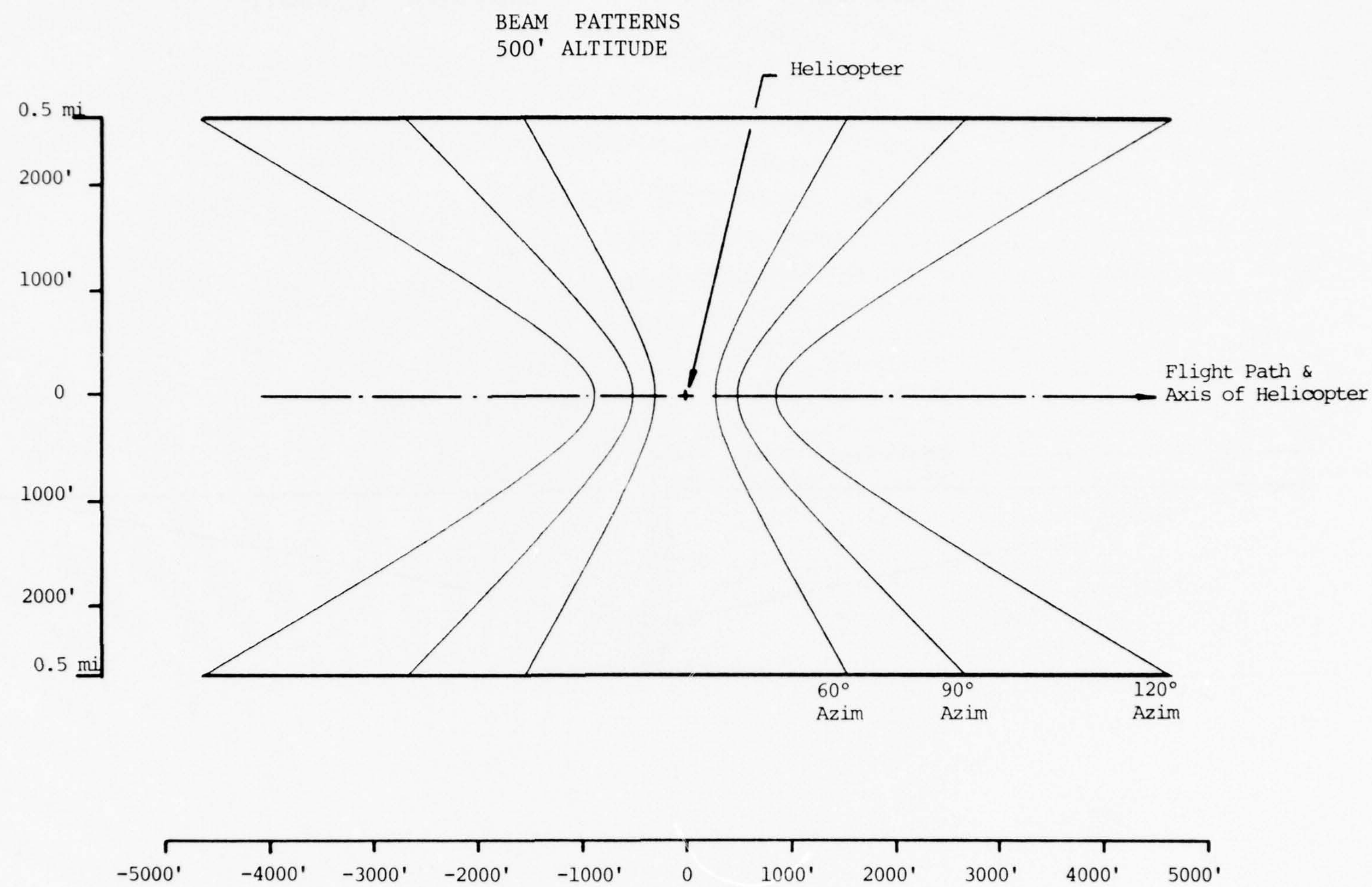


Figure 10. Exact Hyperbolic Beam Patterns

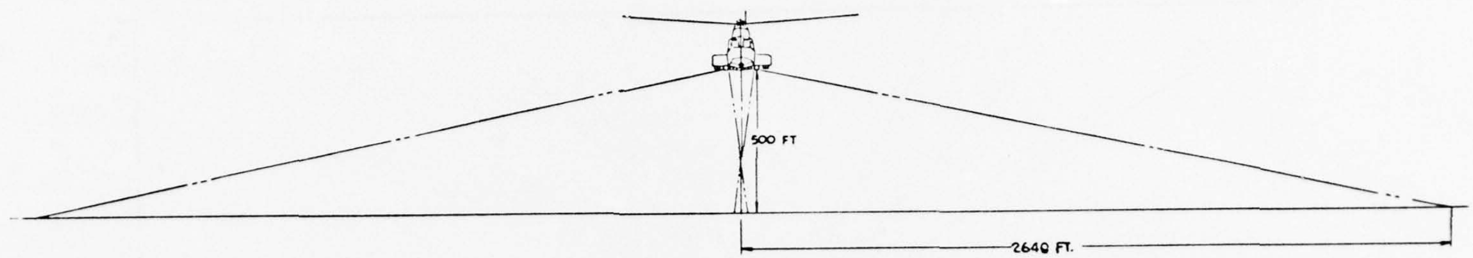


Figure 11. Beam Coverage to Each Side of the Aircraft

APPENDIX A

FORTRAN Code for the Search Model

```
      PROGRAM NBRAV01(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)


         ALL INPUTS ARE READ IN F5.2 ALLWAYS USE DECIMAL POINT
         ALL FIELDS START IN COLLUMS WITH LAST DIGIT OF1 OR 6
         THE INPUTS FOR THIS PROGRAM ARE:
         CONTROL CARDSARE FOR1,ENDS,DONE
         FORU INDICATES THAT A NEW SET OF CONDITIONS FOLLOWS
         ENDS  INDICATES THAT THERE ARE NO MORE INPUTS FOR THIS SET OF
         CONDITIONS HOWEVER OTHER CONDITIONS WILL FOLLOW
         DONE INDICATES THAT THIS IS THE LAST SET OF CONDITIONS
         LITE ONE CARD 9 FIELDS
           FIELD ONE LUMENS OF LIGHT IN 10**5 UNITS
           FIELD TWO ALTITUDE ABOVE WATER OF OBSERVER IN KM,
           FIELD THREE RADIUS OF BEAM PATTERN IN KM.
           FIELD FOUR EFFICIENCY OF REFLECTOR OPTICS
           FIELD FIVE VELOCITY OF HELICOPTER IN KNOTS
           FIELD SIX ANGLE OF BEAM PATTERN ON WATER IN10**2 DEGREES
           FIELD SEVEN SIZE OF TARGET IN X DIRECTION IN METERS
           FIELD EIGHT SIZE OF TARGET IN Y DIRECTION IN METERS
           FIELD NINE VISIBILITY OF ATMOSPHERE IN KM,

         SLGT TWO CARDS WITH 31 FIELDS RELATIVE INTENSITY OF SOURCE
             AT EVERY 10 NANOMETERS STARTING AT 400
         TARG TWO CARDS WITH 31 FIELDS REFLECTANCE OF TARGET
             AT EVERY 10 NANOMETERS STARTING AT 400
         BACK TWO CARDS WITH 31 FIELDS REFLECTANCE OF BACKGROUND
             AT EVERY 10 NANOMETERS STARTING AT 400


       DIMENSION TST(40)
      DIMENSION VC(31),VR(31),VE(31),R(20),T(31),BK(31),SL(31),TG(31),
     1TT(10),P(10),SIG(5)
       DATA VC/ 0.,.001,.004,.012,.023,.038,.06,.091,.139,.208,.323,     CONES
     2 .503,.71,.862,.954,.995,  .995,.952,.87,.757,.631,.503,.381,      CONES
     3 .265,.175,.107,.061,.032,.017,.008,.004                 /         CONES
       DATA VR/.009,.035,.097,.2,.328,.455,.567,.676,.793,.904,.982,     RODS
     2 .997,.935,.811,.65,.481,.329,.208,.121,.09,.033,.016,.007,.005    RODS
     3 ,.003,.001,.001, 4*0,         /                                   RODS
      DATA R/4HLITE,4HATMS,4HSLGT,4HTARG,4HBACK,4H    ,4H    ,4H    ,
     14H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,
     24HFOR1,4HENDS,4HDONE/
  100 READ(5,101)NAME
  101 FORMAT(A4)
  105 READ(5,110)X,(T(I),I=1,15)
  110 FORMAT(A4,1X,15F5.2)
      IF(X    .EQ.R(19).OR.X    .EQ.R(20))GO TO 300
      IF(X.EQ.R(1))GO TO 120
      READ(5,112)(T(I),I=16,31)
  112 FORMAT(16F5.2)
```

```
      IF(X.EQ.R(3))GO TO 140
      IF(X.EQ.R(4))GO TO 150
      IF(X.EQ.R(5))GO TO 160
      IF(X.EQ.R(6))GO TO 170
       GO TO 170
  120 BRITE=T(1)
      HITE=T(2)
      RADI=T(3)
      EFF=T(4)
      VEL=T(5)
      ANGLE=T(6)*100.
      XSIZE=T(7)
      YSIZE=T(8)
      SIG(1)=3.921/T(9)
      D=T(10)/1000.
      GO TO 105
  140 DO 141 I=1,31
  141 SL(I)=T(I)
      GO TO 105
  150 DO 151 I=1,31
  151 TG(I)=T(I)
      GO TO 105
  160 DO 161 I=1,31
  161 BK(I)=T(I)
      GO TO 105
  170 CONTINUE
      WRITE(6,290)X
  290 FORMAT(1H1,//////////A4,1X,37HIS NOT AN IDENTIFIER FOR THIS PROGRA
     1M)
      CALL EXIT
  300 CONTINUE
      IVIS=1
      D1=D*1000.
      V1=3.921/SIG(1)
      WRITE(6,310)BRITE,RADI,ANGLE,V1,D1,EFF
  310 FORMAT(1H1,52HTHIS PROGRAM WILL GIVE PROBABILITY OF DETECTION VS,
     142HTIME FOR VISUAL SEARCH WITH A SEARCH LIGHT////
     15X,30HSEARCH LIGHT PARAMETERS              //
     15X,30HTOTAL FLUX OF SEARCHLIGHT            ,F5.2,3X,15H*10**5 LUMENS  /
     15X,30HRADIUS OF BEAM PATTERN ON H2O        ,F5.2,3X,15HKM.            /
     15X,30HANGLE OF BEAM PATTERN ON H2O         ,F6.2,3X,15HDEGREES        /
     15X,30HATMOSPHERIC VISIBILITY               ,F6.2,3X,8HKM,      /
     15X,30HDISTANCE OF OBSERVER TO LIGHT        ,F6.2,3X,7HMETERS       /
     15X,30HREFLECTOR EFFICIENCY                 ,F5.2    //)
      WRITE(6,320)(SL(I),I=1,31)
  320 FORMAT(1H ,45HNORMALIZED SPECTRAL INTENSITY OF SEARCHLIGHT  //
     27H MICRON,3X,5H  .0 ,5H  .01,5H  .02,5H  .03,5H  .04,5H  .05,5H  .
     306,5H  .07,5H  .08,5H  .09/
     47H   0.4  ,3X,10F5.2/
     57H   0.5  ,3X,10F5.2/
     67H   0.6  ,3X,10F5.2/
     77H   0.7  ,3X,F5.2///)
      WRITE(6,330)VEL,HITE
```

```
 330 FORMAT(1H1,45HHELICOPTER PARAMETERS                                //
    15X,30HVELOCITY OF THE HELICOPTER         ,F5.2,3X,15HKNOTS          /
    25X,30HALTITUDE OF THE HELICOPTER         ,F5.2,3X,10HKM.       /////)
     WRITE(6,335)XSIZE,YSIZE
 335 FORMAT(1H ,45HTARGET-BACKGROUND PARAMETERS                          //
    15X,30HLENGTH OF TARGET                   ,F5.2,3X,7HMETERS   /
    25X,30HWIDTH OF TARGET                     ,F5.2,3X,7HMETERS  //)
     WRITE(6,340)TG
 340 FORMAT(1H ,45HSPECTRAL REFLECTANCE OF THE TARGET            //
    27H MICRON,3X,5H  .0 ,5H  .01,5H  .02,5H  .03,5H  .04,5H  .05,5H
    306,5H  .07,5H  .08,5H  .09/
    47H  0.4  ,3X,10F5.2/
    57H  0.5  ,3X,10F5.2/
    67H  0.6  ,3X,10F5.2/
    77H  0.7  ,3X,F5.2///)
     WRITE(6,350)BK
 350 FORMAT(1H ,45HSPECTRAL REFLECTANCE OF THE BACKGROUND        //
    27H MICRON,3X,5H  .0 ,5H  .01,5H  .02,5H  .03,5H  .04,5H  .05,5H  .
    306,5H  .07,5H  .08,5H  .09/
    47H  0.4  ,3X,10F5.2/
    57H  0.5  ,3X,10F5.2/
    67H  0.6  ,3X,10F5.2/
    77H  0.7  ,3X,F5.2///)
     BRITE=BRITE*100000.
C**
C**       CALCULATE THE RANGE TO TARGET FOR ANGULAR SIZE AND BACKSCATTER
C**
C**
     RMAX=.5*(SQRT(RADI**2+HITE**2)+HITE**2/RADI*(ALOG(RADI/HITE+
    1(RADI**2+HITE**2)**.5/HITE)))
C**
C**       CALCULATE AREA OF BEAM ON THE WATER
C**
     PI=3.14159
     HITE=HITE*1000.
     RADI=RADI*1000.
     RM=SQRT(RADI**2.+HITE**2.)
     ANGIE=ANGLE*PI/180.
     BAREA=HITE**2 * TAN(ANGIE/2.)*ALOG  (-1.*(RADI+RM)/(RADI-RM))+ TAN
    1(ANGIE/2.)*2.*RADI*RM
     HITE=HITE/1000.
     RADI=RADI/1000.
C**
     ALPHA=360./ANGLE
     BETA=ATAN(RADI/HITE)
     SAV=BRITE
     BRITE=BRITE/(4.*PI*ALPHA*SIN(BETA)) *EFF
     ALPHA1=ARCOS(HITE/RMAX)
     RMIN=0
     G=.24
     SI=SIG(1)*.001
     RMIN=RMIN*1000.
     RMAX=RMAX*1000.
```

```
*
*
*       CALCULATE THE BACKSCATTER INTEGRAL
*
      DELTA=(RMAX-RMIN)/40.
      RM=RMIN*2.*SI
      I=0
      BACKS=0.
      TEST=1.
      DO 42 N=1,40
      I=I+1
      BACKS=BACKS+1./EXP(RM   +I*DELTA)/(RM   +I*DELTA)**2
      TST(N)=BACKS
      IF(I.EQ.1)GO TO 46
      TEST=TST(N)-TST(N-1)
   46 CONTINUE
      IF(TEST.LT..0000001)GO TO 44
   42 CONTINUE
   44 CONTINUE
      BACKS=BACKS*G*SI**2*BRITE/2./PI/40.
      RMAX=RMAX/1000.
      B1=0.
      B2=0.
      DO 45 J=1,31
      B1=B1+SL(J)*BK(J)
    5 B2=B2+SL(J)
      BK1=B1/B2

    CALCULATE THE LIGHT LEVEL PRESENTED TO THE EYE


      RITE=SAV*EFF*3./2./PI/RADI**2/PI
      DEYE= RITE/PI/BAREA/.292*(BK1/EXP(2.*SIG(IVIS)* RMAX)+BACKS)
      YL=ALOG10(DEYE)
      A=.5*(1.+ERF((YL+2.5)*.5))
      DO 390 I=1,31
   90      VE(I)=A*VC(I)+(1.-A)*VR(I)
      BC=0.
      BD=0.
      TC=0.
      DO 43 I=1,31
      TC=TC+VE(I)*SL(I)*TG(I)
      BC=BC+VE(I)*SL(I)*BK(I)
      BD=BD+VE(I)*SL(I)
   43 CONTINUE
      BKR=BC/BD
      TGR=TC/BD

    CALCULATE THE CONTRAST PRESENTED TO THE EYE


           C=(TGR-BKR)/EXP(2.*SIG(IVIS)*RMAX)/(BKR/EXP(2.*SIG(IVIS)*RMAX)
```

```
      1+BACKS)
C**
C**
C** CALCULATE THE ANGULAR SIZE PRESENTED TO THE EYE
C**
C**
      AY=YSIZE/RMAX
      AX=XSIZE/RMAX
C**
C**
C** TIME REQUIRED TO FLT OVER SEARCH BEAM PATTERN
C**
C**
      TI=RADI*1000./.515/VEL*PI/ALPHA
C**
C**
C**  CALCULATE THE DETECTION LOBE USING THE LOBE MODEL
C**
C**
      CALL GKD(AX,AY,C,YL,0.,1,3.14,PD,C50,THETO)
      IF(PD.LT..5)GO TO 450
      JC=0
      TH1=0.
      TH2=60.
      METH=1
      SH=3.14
  420  TH=.5*(TH2+TH1)
       CALL        GKD( AX,AY, C,YL.TH  ,METH,SH,PD,C50,THETO          )
      JC=JC+1
      PDM=PD-.5
      ADM=ABS(PDM)
      IF(JC.GT.30)GO TO 450
      IF(ADM.LT..001)GO TO 470
      IF(PDM)430,470,440
  430 TH2=TH
      GO TO 420
  440 TH1=TH
      GO TO 420
  450 WRITE(6,460)
  460 FORMAT(1H ,46HNO LOBE SIZE EXISTS FOR YOUR SET OF CONDITIONS)
      GO TO 999
C**
C**
C** CALCULATE THE PROBABILITY OF DETECTION FOR ONE FLY BY
C**
C**
  470  AREAS=ANGLE/360.*PI*RADI**2.
      WRITE(6,465)C,AX,AY,DEYE,TH
  465 FORMAT(1H ,45HCALCULATED TARGET AND LIGHT LEVEL PARAMETERS  //
     15X,30HTARGET CONTRAST                    ,F5.2/
     25X,34HANGULAR TARGET SIZE IN X DIRECTION,F5.2,3X,10HMRAD.         /
     35X,34HANGULAR TARGET SIZE IN Y DIRECTION,F5.2,3X,10HMRAD.         /
     45X,34HLIGHT LEVEL PRESENTED TO THE EYE  ,  E9.3,10HFT. LAMB,      /
```

```
     5SX,34HDETECTION LOBE SIZE                    ,F5.2,3X,10HDEGREES      )
      ATH=((TAN(TH*PI/180.)*HITE)**2)*PI
      DO 480 I=1,10
      TT(I)=.1*FLOAT(I)*TI
  480 P(I)=1.-1./EXP(ATH*3.*TT(I)/AREAS)
      WRITE(6,490)(TT(10),P(10))
  490  FORMAT(1H1,33HPROBABILITY OF DETECTION VS. TIME //
     15X,24H TIME TARGET WAS IN BEAM,6X,25H PROBABILITY OF DETECTION/(
     214X,F5.2,27X,F5.2))
  999  IF(X    .EQ.R(20))GO TO 1000
      GO TO 100
 1000 STOP
      END
```

```
      SUBROUTINE GKDC AX,AY, C,YL,THET,METH,SH,PD,C50 ,THETO          )

C  AX,AY ARE LENGTH AND WIDTH OF THE TARGET IN MILLIRADIANS
C  AY  IS SMALLER THAN AX FOR RECTANGLES
C  C =  TARGET CONTRAST
C  YL = LOG LIGHT LEVEL IN FOOTLAMBERTS
C  THE= IS ECCENRICITY ANGLE IN DEGREES
C  SH =  SHIFT IN CONTRAST. ( WE ADVISE SH SOMEWHERE BTEEN 3 AND 10 )
C  PD = DETECTION PROBABILITY
C  C50 = LIMINAL CONTRAST FOR 50 PERCENT DETECTION PROBABILITY
C  THETO = ECCENTRICITY  ANGLE FOR OPTIMUM PERFORMANCE ( 0 ONLY AT HIGH LL)


C  EVEN NUMBERED METHODS ARE CORRECTED FOR TOO SMALL CONTRASTS REDUCING
C  THE PROBABILITY THAT THE CORRECT MATCHED FILTER IS CHOSEN.
C  THIS CORRECTION IS MOST DOMINENT IN FORCED CHOICE AND/OR LONG OBSERVATION
C  TIME EXPERIMENTS

C  METHODS LARGER OR EQUAL TO 5 FIXATE AT OPTIMUM ANGLE THETO

C  METH =  1 INPUTS YL,C,THET,SH      OUTPUT PD, C50   (UNCORRECTED )
C            USE SH 3 TO 10 FOR SHORT GLANCE TIME PROBABILITIES
C  METH =  2 INPUTS YL,C,THET,SH      OUTPUT PD, ( CORRECTED FOR SMALL C )
C            THIS METHOD MIGHT BE USED FOR LOW SPATIAL FREQUENCY CLUTTER
C  METH =  3   SHORTENED VERSION OF METH = 1 (WITHIN 5 PERC. OF ERROR)
C            USE INSTEAD OF METHOD 1 IF SPEED IS OF ESSENCE OR IF YOU WANT
C            TO TEST ITS INVERSION (METHOD 11 )
C  METH =  4 INPUTS YL,C,THET,SH      OUTPUT C50 ( CORRECTED FOR SMALL C )
C            USE SH = 1  TO RECONSTRUCT LINGE≤S CURVES
C  METH =  5 INPUTS YL,C,SH      OUTPUT PD, C50 ON FIXATION  (UNCORRECTED )
C            USE FOR SHORT OBSERVATION TIME DATA WHEN FIXATION POINT IS KNOWN
C  METH =  6 INPUTS YL,C,SH      OUTPUT PD,  ON FIXATION (CORRECTED FOR SMALL C
C            USE WITH SH = 1 FOR P(INFINITY) OF EASY TASKS. FOR NON EVEN
C            BACKGROUNDS USE SH ≡ 1.
C  METH =  7   SHORTENED VERSION OF METH = 5 (WITHIN 5 PERC. OF ERROR)
C              USE INSTEAD OF METHOD 5 IF VERY MANY RUNS ARE REQUIRED
C  METH =  8 INPUTS YL,C,SH      OUTPUT C50, ON FIXATION (CORRECTED FOR SMALL C
C            USE SH = 1 TO RECONSTRUCT BLACKWELL≤S CURVES
C  METH = 11 INPUTS YL,C,SH           OUTPUT THET       (UNCORRECTED )
C            USE SH 3 TO 10 FOR FOR LOBE RADIUS = THET
C            COMPARISON TO THET DERIVED BY METH = 1 WILL GIVE AN ERROR OF
C            LESS THAN 5 MINUTES OF ARC. METHOD 11 IS A CLOSED FORM INVERSION
C            OF METHOD 3 THUS THE COMPARISON IS LIMITED BY COMPUTER PRECISION


      DATA PI,PII4,SQPII4  /3.1416,1.27324,1.62114   /
      DATA RI,RH,SQRI,SQRH / 3., 2., 9., 4.   /
      DATA RLOG,RTISUM,RILOG,RHLOG/.523248,.781736, 1.09861,.693147/
      DATA GELOC,GELOR,B1C,B1R,B3C,B3R /.6,.9,.18,6.,.1,.007  /
      DATA B0,B4, C00,ROOT10 / 15.,.21,.008, 3.16228 /
      DATA TNOR1,TNOR2,TNOR12,XKO /.124417,.816223,.15243,70.276 /

C  RI = THE RATIO BETWEEN EXCITATION AND INHIBITION SPREAD FUNCTION WIDTH
```

```
C   RI = (GE/GI),   RH = (2,*GE)/(GE+GI),   SQRI = RI*RI,   SQRH = RH*RH
C   THE DATA CARD VALUES ARE THE SPECIAL CASE WHEN RI = 3.
C   PII4 = 4./PI,   SQPII4= PIIJ**2
C   RILOG=ALOG(RI),    RHLOG=ALOG(RH),     RLOG=RI*ALOG(RI)-2.*RH*ALOG(RH)
C   RTISUM = SQRT(1. + (1,/RI)**2 - 2,*(1,/RH)**2 )
C   TNOR1 = RTISUM/(2,*PI)       TNOR2=SQRT(PII4*RLOG)    TNOR12 = TNOR1/TNOR2
C
C   GELOC, GELOR ARE CONE ROD MINIMAL RESOLUTION LENGTHS
C               VALUES OF B ARE NORMALIZED CONSTANTS TO FIT BOUMAN VOS AND
C   WALRAVEN<S FINITE NEURAL REFRACTORY  TIME THORY ( THE LAST LETTER C AND
C   R DENOTE CONE AND ROD WHEN APPLICABLE
C
C IF YL = -2.5    NS = N**2/(N**2*B1C + N +B3C )
C IF YL ) -2.5    NS = N**2/(N**2*B1R + N +B3R )
C        WHERE N IS PROPORTIONAL TO LIGHT LEVEL WITH PUPIL AND TIME CORRECTIONS
C   THE CORRECTION FACTOR TO EXPRESSES THE PUPIL AND INTEGRATION TIME INCREASE
C   WITH DECREASING LIGHT LEVEL
C
C
1010     FORMAT(1X,10E12.4)
1011     FORMAT(1X,10F12.8)
C
C   METH2 SEPARATES EVEN FROM ODD METHODS
         METH2=METH-2*(METH/2)
C   DEFAULT VALUE OF SH = 1.
         IF(SH,LT,.0001)  SH=1.
501      XL=3.-YL
         XL1=XL-1.47
         XL2=XL-3.2
         IF(XL1.LT.0.) XL1=0.
         IF(XL2.LT.0.) XL2=0.
    IMPIRICAL ADJUSTMENTS FOR THE INVERSIONS
         THEXP=2.
         THET0=.4*XL2**2
         TCOR=.4
         IF(XL1,LT,.01)        GO TO 15
         TNORM=1.+.2*XL1
         TCOR=TCOR/TNORM
 5       T0=60*EXP(B4*XL1)
         GEXP=.5
    NORMALIZED NUMBER OF PHOTONS
         XKL=9000./10.**XL
         RXKL=SQRT(XKL)
    SHIFTED CONTRAST
         CC=ABS(C)/SH
         IF(CC.LT..000001)      CC=.5/SH
         P101=1.
    GEL = RESOLUTION LENGTH,  QL = SENSITIVITY
    AT LOG(LL) = -2.5 A BRANCH POINT BETWEEN ROD AND CONE ACTIONS OCCURS
         IF(YL.LT.-2.5)     GO TO 10
         GEL=1.25**XL1*GELOC
         QL =XKL/(B1C*XKL + RXKL + B3C )*T0
         GO TO 12
```

```
10      GEL=1.4**(XL-4.12)*GELOR
        QL =XKL/(B1R*XKL + RXKL + B3R )*T0  *.6
C   ONLY EVEN NUMBERED METHODS HAVE P101 NOT NECESSARILY UNITY
12      IF(METH2.EQ.1)   GO TO 11
        C0=C00 *SQRT(XK0/QL )*(GELOC/GEL)
        SL1=.8
        P101=.5*(1.+ERF(ALOG(CC/C0)*SL1))
11      SQGEL=GEL*GEL
        IF(METH.GT.10) GO TO 110
C   METHODS GREATER OR EQUAL TO 5 ALWAYS FIXATE AT THETO
        IF(METH.GE.5) GO TO 58
C   RESOLUTION LENGTH IS INCREASED AND SENSITIVITY DECREASED
        THDIF=ABS(THET-THETO)+.00001
        TNC=(1.+(TCOR*THDIF)**THEXP)**GEXP
        GEL=GEL*TNC
        QL=QL/TNC**2
58      AXE=AX/GEL   *.5
        AYE=AY/GEL   *.5
        IF(METH.EQ.3.OR.METH.EQ.7)    GO TO 75
C   RIGOROUS DERIVATION OF PROBABILITY AND C50
        AXI=AXE/RI
        AXH=AXE/RH
        AYI=AYE/RI
        AYH=AYE/RH
        SQGEL=GEL*GEL
        IF(AXE.LT..1)  GO TO  68
        IF(AYI.GT.1000.)  GO TO  65
        IF(AYI.LT.1.18) GO TO 72
        T1XE = 1. + ALOG(AXE)
        T1YE = 1. + ALOG(AYE)
        T2XE = PTL(AXE)
        T2YE = PTL(AYE)
        T2XI = PTL(AXI) - RILOG
        T2YI = PTL(AYI) - RILOG
        T2XH = PTL(AXH) - RHLOG
        T2YH = PTL(AYH) - RHLOG
        SQT1=-PII4*GEL*((T2XE+RI*T2XI-2.*RH*T2XH) *AY   +(T2YE+T2YI*RI
     * -2.*RH*T2YH)*AX ) +SQPII4*SQGEL*((T2XE+T1XE)*(T2YE+T1YE)
     *+SQRI*(T2XI+T1XE)*(T2YI+T1YE) - 2.*SQRH*(T2XH+T1XE)*(T2YH+T1YE))
        IF(SQT1.LT..00000001) GO TO 65
        T1=SQRT(SQT1)
        GO TO 80
65      T1 =SQRT(PII4*GEL*(AX+AY)*RLOG)
        GO TO 80
72     SQT1=SQPII4*SQGEL*(TLO(AXE)*TLO(AYE)+SQRI*TLO(AXI)*TLO(AYI)
     * -2.*SQRH*TLO(AXH)*TLO(AYH))
        IF(SQT1.LE..00000001) GO TO 68
        T1=SQRT(SQT1)
        GO TO 80
68      T1=.125*PII4  *  AX*AY/GEL*RTISUM
        GO TO 80
C   APPROXIMATE DERIVATION OF T1
75     T12=.125*PII4  *  AX*AY/GEL*RTISUM
```

```
      T11=SQRT(PII4*GEL*(AX+AY)*RLOG)
      ABAR=SQRT(AX*AY)
      RAT=AX/ABAR
      EXPO=1.4-.2*RAT*(1.-.05*RAT)
      IF(EXPO.LT..5) EXPO=.5
      T1=T11*T12/(T11**EXPO+T12**EXPO)**(1./EXPO)
80    C50=1./(QL*T1)
      SL2=.8
      TERM=ALOG(CC/C50)*SL2
      PD= .5*(1.+ERF(TERM))       *P101
      IF(METH.EQ.4.OR.METH.EQ.8)      GO TO 59
      GO TO 100
C WHEN P101 NOT 1. C50 IS EVALUATED BY GOLDEN CHOICE METHOD
59    C50L=ALOG(C50)
       C0L=ALOG(C0)
      CDIF=C50L-C0L
      DIF2=-2.5/SL2
      DIF1= 2.5/SL1
      IF(CDIF.GT.DIF1)  GO TO 97
      IF(CDIF.LT.DIF2)  GO TO 96
      C1=C0L
      C2=C1+DIF1
      JCOUNT=0
511   CH=.5*(C1+C2)
      JCOUNT=JCOUNT+1
      TERM1=(CH- C0L) *SL1
      TERM2=(CH-C50L) *SL2
      PD=.25*(1.+ERF(TERM1))*(1.+ERF(TERM2))
      PDM=PD-.5
      ADM=ABS(PDM)
      IF(JCOUNT.GT.30)  GO TO 55
      IF(ADM.LT..001) GO TO 56
      IF(PDM) 53,56,54
53    C1=CH
      GO TO 511
54    C2=CH
      GO TO 511
55    WRITE(6,981)  YL,A
981   FORMAT(40HWARNING WE NEEDED 30 ITERATIONS AT LL, A ,2F9.4)
56    CONTINUE
      IF(CH.GT.10.)     CH=10.
      C50=EXP(CH)
      GO TO 97
96    C50=C0
97    CONTINUE
      GO TO 100
C  CLOSED FORM INVERSION OF THE APPROXIMATE METHOD BY SOLUTION OF A QUADRATI
C  EQUATION
110   CONTINUE
      ABAR=SQRT(AX*AY)
      RAT=AX/ABAR
      EXPO=1.4-.2*RAT*(1.-.05*RAT)
      IF(EXPO.LT..5) EXPO=.5
```

```
      AK=TNOR12/SQRT(RAT+1./RAT)
      TERM1=(AK*(ABAR/GEL)**1.5)**EXPO *.5
      TERM2 = (TNOR1    *CC*ABAR*ABAR/GEL*QL )**EXPO
      THEXPI=1./THEXP
      GEXPI=.66666666/(GEXP*EXPO)
      FTHET=(SQRT(TERM1*TERM1+TERM2)-TERM1)**GEXPI
      THE =FTHET-1.
C  LOBE RADII CAN NOT BE LESS THAN THETO
      IF(THE .LT..000001)    GO TO 115
      THET=THE **THEXPI/TCOR+THETO
      GO TO 100
C  NO LOBE
115   THET=0.
100   CONTINUE
      RETURN
     END
```

```
      FUNCTION TLO(X)
C
C                                                                  K=M
C                                                                  ---
C                                                                   .   (-1)**K * X**(
C              ( WHEN X = 1 )         := X*PI/2-1-ALOG(X)+ =  -------------
C                                     ;                             .        (2*K+1)*2
C                                     ;                            ---
C                                     ;                            K=1
C  TLO(X) = X*ATAN(X)+.5*ALOG(X*X+1.);
C                                     ;      K=M
C                                     ;      ---
C                                     ;       .      (-1)**(K+1) * X**(2*K)
C              ( WHEN X ) 1 )         ; =     =      ---------------------
C                                             .      (2*K-1) * 2*K
C                                            ---
C                                            K=1
C
C  TO PREVENT IMPRECISIONS  CAUSED CANCELLATIONS THE INFINITE SERIES
C  ARE USED WHEN ARGUMENTS ARE LARGE AND SMALL
C  THE UPPER LIMIT OF THE SERIES EXPANSION, M, IS CHOSEN FOR 4 SIGN. FIG.
C
      IF(X.LT..01)          GO TO 10
      IF(X.GT.100.)    GO TO 30
      IF(X.LT..1)           GO TO 5
      IF(X.GT.10.)     GO TO 20
      TLO=X*ATAN(X)-.5*ALOG(X*X+1.)
      GO TO 50
5     XX=X*X
      TLO=.5*XX*(1.-.16666667*XX*(1.-.4*XX))
      GO TO 50
10    XX=X*X
      TLO=.5*XX*(1.-.16666667*XX)
      GO TO 50
20    XX=1./(X*X)
      P=1.5708
      TLO=P*X-(1.+ALOG(X))-.16666667*XX*(1.-.3*XX)
      GO TO 50
30    XX=1./(X*X)
      P=1.5708
      TLO=P*X-(1.+ALOG(X))
50    RETURN
      END
```

```
PTL          74/74    OPT=1                                  FTN 4.6+420
                                                                          09/20/76
      FUNCTION PTL(X)
C
C
C              K=M
C              ---
C               .    (-1)**(K+1) * X**(-2*K)
C     PTL(X) = =    -----------------------                  WHEN X ≥ 1.18
C               .    (2*K+1) * 2*K
C              ---
C              K=1
C
C  THE UPPER LIMIT OF THE SERIES EXPANSION, M, IS CHOSEN FOR 4 SIGN. FIG. PRES
C
      XX=1./(X*X)
      IF(X.GT.10.)   GO TO 10
      IF(X.GT.2.5)   GO TO 20
      IF(X.GT.2.)    GO TO 25
      IF(X.GT.1.4) GO TO 30
40    PTL=.16666667*XX*(1.-.3*XX*(1.-.4761905*XX*(1.-.58333333*XX*
     2(1.-.65454545*XX*(1.-.7051282*XX*(1.-.7428571*XX*(1.-.7720588*XX*
     3(1.-.7953216*XX*(1.-.8142857*XX*(1.-.8300395*XX*(1.-.84333333*XX
     4*(1.-.8547009*XX*(1.-.864532*XX*(1.-.8731182*XX*(1.-.88068*XX))))
     * ))))))))))
      GO TO 50
10    PTL=.16666667*XX
      GO TO 50
20    PTL=.16666667*XX*(1.-.3*XX*(1.-.4761905*XX*(1.-.58333333*XX)))
      GO TO 50
25    PTL=.16666667*XX*(1.-.3*XX*(1.-.4761905*XX*(1.-.58333333*XX*
     2(1.-.65454545*XX*(1.-.7051282*XX*(1.-.7428571*XX))))))
      GO TO 50
30    PTL=.16666667*XX*(1.-.3*XX*(1.-.4761905*XX*(1.-.58333333*XX*
     2(1.-.65454545*XX*(1.-.7051282*XX*(1.-.7428571*XX*(1.-.7720588*XX*
     3(1.-.7953216*XX*(1.-.8142857*XX*(1.-.8300395*XX ))))))))))
      GO TO 50
50    RETURN
      END
```

```
      FUNCTION ERF(X)
      AX=ABS(X)
      P=.3275911
      T=1./(1.+P*AX       )
      A1=.254829592
      A2=-.284496736
      A3=1.421413741
      A4=-1.453152027
      A5=1.061405429
      IF(AX.GT.16.)GO TO 10
      ERF=1.-(A1*T+A2*T**2+A3*T**3+A4*T**4+A5*T**5)/EXP(AX**2)
      IF(X.LT.0.)ERF=-1.*ERF
      RETURN
   10 ERF=1.
      RETURN
      END
```

```
FUNCTION ARCOS(X)
ARCOS=ACOS(X)
RETURN
END
```

APPENDIX B

Purchase Description for Illuminator

1. SCOPE

1.1 This purchase description establishes performance, design and test requirements for a Wide Area Illumination System (WAILS) for use on the HH-3F helicopter for Coast Guard search and rescue operations.

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on date of invitation for bid or request for proposal, form a part of this purchase description to the extent specified herein:

SPECIFICATIONS

Military

MIL-T-152	Treatment, moisture and fungus resistant, of communication electronic and associated electrical equipment.
MIL-D-1000	Drawings, Engineering and Associated Lists
MIL-B-5087	Bonding, Electrical, and Lighting Protection, for Aerospace Systems
MIL-W-5088	Wiring Aircraft Installation of #ASG#
MIL-E-5400	Electronic Equipment, Airborne, General Specification for
MIL-C-6021	Castings, Classification and Inspection of
MIL-E-6051	Electrical, Electronic System Compatibility and Interference Control Requirements
MIL-I-6181	Interference Control Requirements Aircraft Equipment
MIL-P-11268	Parts, Materials and Processes Used in Electronic Equipment
MIL-C-25050	Color, Aeronautical Lights and Lighting Equipment, General Requirements for
MIL-H-46855	Human Engineering Requirements for Military Systems, Equipment and Facilities

STANDARDS

Military

MIL-STD-100	Engineering Drawing Practices
MIL-STD-130	Identification and Marking of U.S. Government Property
MIL-STD-171	Finishing of Metal and Wood Surfaces
MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-STD-461	Electromagnetic Interference Characteristics Requirements for Equipment
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-704	Electric Power, Aircraft Characteristics and Utilization of
MIL-STD-810	Environmental Test Methods
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities

3. REQUIREMENTS

3.1 Item Definition. The WAILS covered by this purchase description shall be an illumination system which will be installed and used on the Coast Guard HH-3F helicopter for search and rescue operations at night. The system shall provide visible illumination for detection of various targets with a seawater background. The WAILS shall consist of the following major components which shall be developed:

a. Luminaires
b. Mounting pods
c. Power supply
d. Electrical cables

3.1.1 Item diagram. The functional block diagram of the WAILS shall be as shown in Figure 1.

3.1.2 Interface definition

3.1.2.1 Helicopter system interface. The contractor shall be responsible for complete mechanical, electrical, and functional integration of the WAILS on the HH-3F test helicopter. All required integration hardware shall be supplied by the contractor. The recommended mounting location for the mounting pods and luminaires is as shown on Figure 2.

3.1.2.2 Functional interface of major components. The electrical interconnection diagram for the WAILS shall be as shown on Figure 3. Functions of the major components are listed below.

3.1.2.2.1 Luminaires. The luminaires shall project the light beam away from the helicopter.

3.1.2.2.2 Mounting pods. The mounting pods shall attach to the helicopter and shall serve as the mounting structure for the luminaires.

3.1.2.2.3 Power supply. The power supply shall condition the power obtained from the helicopter power source and provide ignition power and power for steady state operation of the WAILS. The power supply shall also include the power switches for the WAILS.

3.1.2.2.4 Electrical cables. The electrical cables shall route electrical power from the helicopter power source to the power supply and from the power supply to the luminaires.

3.1.3 Major components list. The following major components of the WAILS are all defined in this purchase description.

a. Luminaires
b. Mounting pods
c. Power supply
d. Electrical cables

3.1.4 Government furnished property list. No Government furnished property is required to be incorporated in the design of the WAILS.

3.1.5 Government loaned property list. No Government loaned property is anticipated.

3.2 Characteristics

3.2.1 Performance

3.2.1.1 Starting, normal operation and restarting. The lamps of the luminaires shall ignite and maintain ignition within 0.5 minute after application of ignition power under any environment specified herein. The lamps shall emit at least 80 percent of their full light output within 5 minutes after application of ignition power under any environment specified herein. Total system power consumption shall not exceed 10 KVA. The lamps shall be capable of reignition within no more than five minutes after power shut-off.

3.2.1.2 Cooling. The luminaires and mounting pods shall be designed such that the temperature of the outer metal surface of the combination shall not exceed 60 °C when operating under standard ambient conditions as stated in MIL-STD-810 for a period of at least 15 minutes after ignition. Also, operation of the WAILS on the helicopter for a period of at least 15 minutes shall not result in an increase in the aircraft skin temperature of more than 10 °C.

3.2.1.3 Illumination. The WAILS shall be designed to provide illumination of at least 0.02 foot candles over an area of at least 8.0×10^6 square feet on each side of the helicopter (16.0×10^6 ft^2 total) with the helicopter operating at an altitude of 500 feet. Illumination shall be provided from directly under the helicopter to a distance of 0.5 mile (2640 feet) to each side of the helicopter at this altitude.

3.2.1.4 Total flux. The total light flux emitted by the lamps of the WAILS shall be at least 12.0×10^5 lumens. Total usable flux emitted from the luminaires shall be at least 6.0×10^5 lumens.

3.2.1.5 Azimuthal beamspread. The azimuthal beamspread (see 6.3) of the WAILS shall be at least 80 degress but not more than 120 degrees. The centerline of the beam in azimuth shall be perpendicular to the axis of the helicopter (See Figure 4).

3.2.2 Physical characteristics

3.2.2.1 Size. Size of the WAILS components shall be as specified in 3.5.

3.2.2.2 Weight. Total weight of the WAILS shall not exceed 250 pounds.

3.2.2.3 Power switches. The power supply shall include two power switches. One switch shall control power to the luminaires which illuminate the area on the starboard side of the helicopter. The other switch shall control power to the luminaires which illuminate the area on the port side of the helicopter. These switches may also be the manually resettable overload protection devices referred to in 3.3.2.5.

3.2.2.4 Indicator lamps. Green indicator lamps shall be provided on the power supply to indicate when the lamps in the luminaires are lit. One indicator lamp shall be provided for each luminaire. The color of the indicator lights shall be in accordance with MIL-C-25050.

3.2.2.5 Elapsed time meters. Two elapsed time meters shall be provided to indicate total on-time for each bank of luminaires. The meters shall be mounted on the power supply.

3.2.3 Reliability. As a design objective, the reliability of the WAILS shall exhibit a minimum mean-time-between-failures (MTBF) of at least 1000 hours.

3.2.4 Maintainability. The WAILS shall have easy access for relamping and other maintenance operations. The power supply and luminaires shall have appropriate test points provided for troubleshooting procedures in accordance with paragraph 5.9 of MIL-STD- 1472. Only common hand tools and test equipment shall be required for maintenance of the WAILS.

3.2.5 Environment conditions. The WAILS shall comply with all the requirements and not sustain damage (see 6.3) when subjected to the environmental conditions listed below.

3.2.5.1 Humidity. The equipment shall be operable and provide satisfactory operation after completion of Method 507, Procedure II of MIL-STD-810.

3.2.5.2 Vibration. The equipment shall be operable without degradation in specified performance, and shall sustain no damage, when exposed to vibration levels up to 2g's over a frequency range of 5 to 500 cps. when using Procedure I, Method 514 of MIL-STD-810.

3.2.5.3 Shock. The equipment shall be designed to withstand 20g shock input without damage. In addition, the equipment mounting devices with maximum rated load applied shall withstand 40g shock input without physical failure, however, bending and distortion shall be permitted. Shock pulses shall be in accordance with MIL-STD-810, Method 516. The equipment shall also not be damaged by impact with the water at a velocity of 500 feet per minute. Testing for this requirement is not required.

3.2.5.4 Sand and dust. The equipment shall be designed to be resistant to malfunction from blowing fine sand and dust particles, as specified in Procedure I, Steps 1 and 4 of Method 510, MIL-STD-810. Testing for this requirement is not required.

3.2.5.5 Rain. The WAILS shall be capable of operating after being exposed to heavy rain as encountered on the ground or during flight. Testing for this requirement is not required.

3.2.5.6 Immersion. The WAILS shall be designed to function as specified when immersed in salt water in accordance with the procedures as specified in Method 512 in MIL-STD-810.

3.2.5.7 Explosive atmosphere. The WAILS shall not cause ignition of an ambient-explosive-gaseous moisture with air when operating in such an atmosphere. (MIL-STD-810, Method 511.1 Procedure I).

3.2.5.8 Temperature - altitude. The WAILS shall be capable of continuous operation over a temperature range of -35°C to +55°C under combined temperature altitude conditions of Method 504, Procedure I of MIL-STD-810 for equipment Class 1A.

3.3 Design and construction

3.3.1 Materials processes and parts. All parts, materials and processes used in the construction of the searchlight shall be in accordance with MIL-P-11268.

3.3.1.1 Responsibility for part and material selection. The selection of the class, grade or type of part or material shall be such that when installed in the searchlight, the part or material shall perform its intended function. Unless otherwise specified herein, parts and materials shall be selected by the contractor, subject to the requirements of this specification.

3.3.1.2 Treatment and painting. All metal surfaces except for electrical contacts shall be treated to prevent corrosion and electrolytic action between dissimilar metals. External metal surfaces shall be treated in accordance with specification MIL-STD-171. Since the system will be operating in a salt water environment, special care shall be taken in the selection of materials (metals) and treatment thereof which will resist this caustic environment.

3.3.2 Power. The WAILS shall receive its electrical power from the helicopter and shall be fully compatible with the available aircraft power. It shall operate in accordance with the provisions of MIL-STD-704. The system shall operate and maintain minimum performance requirements during abnormal operation of the electrical system as specified in MIL-STD-704. Momentary loss of power shall not preclude reignition of the lamps and shall not cause the mission to be aborted. The following electrical power will be made available for the system use:

Power Form	Maximum Available Power
115/208 VAC, 400 HZ, 3 Phase	10 KVA

3.3.2.1 Protection against AC phase reversal damage. Provision shall be made to prevent phase reversal from damaging the WAILS.

3.3.2.2 Wiring. All electrical wiring shall meet the requirements of MIL-W-5088.

3.3.2.3 Cables and connectors. The WAILS shall be designed for the use of cables and connectors in accordance with MIL-E-5400 and also to operate satisfactorily using external wiring designed in accordance with the applicable requirements of MIL-W-5088. External wiring shall be unshielded, except that a minimum number of individual wires may be shielded when demonstrated as necessary to meet the interference control requirements, and provided the assembly of the cable to its plugs may be easily accomplished.

3.3.2.4 Bonding and grounding. The WAILS shall have adequate provisions for bonding to the aircraft structure and achieving the 2.5 milliohms bonding impedance specified in paragraph 3.3.5.1 of MIL-B-5087. Bonding shall not be accomplished through screws connecting the equipment to mounting racks. Shock-mounted equipment and those employing vibration isolators must utilize bonding straps to bypass the mount or isolator and achieve a low impedance bond to the equipment ground plane. Bonding techniques employed shall be in accordance with MIL-B-5087, and shall not impede maintainability nor adversely affect interchangeability of equipment as installed in the aircraft.

3.3.2.5 Electrical overload protection. The WAILS shall contain overload protection devices for all internal power supplies which could be damaged by surge short or open circuit load. The protection devices shall be automatically resettable when overload conditions cease to exist in accordance with MIL-STD-704. The WAILS shall also have manually resettable overload protection devices to protect the aircraft power system.

3.3.2.6 Undervoltage protection. The WAILS shall not be damaged by voltages below the minimum specified in MIL-STD-704 and shall automatically resume normal operation when the voltage returns to the specified limits.

3.3.3 Hermetically sealed semiconductors and integrated electronics. Only hermetically sealed (non-plastic) packages of semiconductor devices, used either as discrete or as integrated electronics, shall be utilized in this equipment.

3.3.4 Insulating and impregnating compounds. Insulating and impregnating compounds shall not support rapid combustion. (MIL-STD-454) Impregnating compounds shall not lessen the dielectric strength of, or cause injurious effects to the insulation. Impregnating compounds shall not cause corrosion of deterioration of adjacent metal or plastic parts, either on original application or as a result of aging.

3.3.5 Fungus moisture resistance and salt fog. The electrical circuitry, including all components and connections, shall be protected from the effects of moisture, fungus growth and salt fog by an overall treatment conforming to specification MIL-T-152 Type II limited treatment excepting that components of circuit elements that are inherently fungus and moisture resistant or which are hermetically sealed need not be treated.

3.3.6 Electromagnetic radiation. The electromagnetic compatibility of the WAILS shall conform to MIL-STD-461 equipment Class 1D except during ignition. When integrated into the aircraft, the WAILS shall meet the requirements of MIL-E-6051 and MIL-I-6181.

3.3.7 Nameplates and product marking. The WAILS shall be identified and marked in accordance with MIL-STD-130. Transfer type decalcomanias shall not be used. Reference designation markings shall be permanent and legible. Plastic or metallic material shall be marked by stamping, engraving, silk screening, stenciling or by applying smudgeproof ink covered by a clear coat of lacquer.

3.3.8 Workmanship. Workmanship shall be in accordance with requirements of MIL-STD-454. Joints or seams shall fit tightly. Edges shall be finished smoothly. All parts and components of the searchlight shall be free from dirt or other extraneous material and from defects of workmanship that would impair the performance of the searchlight.

3.3.9 Interchangeability. Assemblies and parts shall be functionally and dimensionally interchangeable without selective assembly in accordance with the requirements of MIL-STD-454. The mounting hardware for the WAILS shall have sufficient adjustment range to allow for proper installation on any Coast Guard HH-3F helicopter.

3.3.10 Safety. The WAILS shall be designed and fabricated to prevent injury to operating and maintenance personnel. All components shall conform to requirement 1 of MIL-STD-454. The wiring shall be effectively shielded, guarded, interlocked or marked to protect personnel from electrical shock hazard.

3.3.11 Human performance/human engineering. The searchlight shall be designed to meet the human performance/human engineering requirements of MIL-H-46855 and MIL-STD-1472.

3.4 Documentation. The WAILS shall be documented by drawings prepared in accordance with MIL-D-1000 and MIL-STD-100, Level 1.

3.5 Major component characteristics. The performance and physical characteristics of the major components shall be as specified in the following paragraphs:

3.5.1 Luminaires. The luminaires shall have a lamp, a lamp holder/socket assembly, a reflector, a housing, a cover plate and an electrical connector. The luminaire shall be well gasketed and sealed so as to be water tight. The luminaire shall be designed so that the product of the collection, reflection and window transmission efficiencies shall be at least 50 percent.

3.5.1.1 Lamp. The lamp shall be a high pressure sodium vapor arc lamp.

3.5.1.2 Lamp holder/socket assembly. The lamp holder/socket assembly shall hold the lamp securely, prevent excessive vibration and allow easy removal and replacement of the lamp.

3.5.1.3 Reflector(s). The reflector(s) shall be of the specular type with average reflectance in the visible (wavelength range 400 to 750 nanometers) of at least 80 percent. The reflector(s) shall be designed to collect at least 65 percent of the light emitted by the lamp.

3.5.1.4 Housing. The housing of the luminaire shall be made of cast aluminum in accordance with MIL-C-6021. It shall include hardware for mounting the complete luminaire to the mounting rack and for adjustment of the luminaire orientation to vary the position of the beam in elevation.

3.5.1.5 Cover plate. The cover plate shall be hinged for access for relamping and shall have a clear flat glass window capable of withstanding the thermal shock specified herein.

3.5.2 Mounting pods. The mounting pods shall be capable of quick attachment and detachment from the hard points on the helicopter.

3.5.3 Power supply. The power supply shall have a volumetric displacement of no more than 5.0 cubic feet.

3.5.4 Electrical cables. Electrical cables shall be of a length for proper installation and operation of the WAILS on the helicopter.

3.6 Precedence. In the event of conflict between this purchase description and any document referenced herein, the requirements of this purchase description shall govern. The characteristics of the searchlight shall have priority as follows:

a. Performance
b. Safety
c. Reliability
d. Maintainability
e. Human Factors
f. Weight
g. Size

3.7 Test plan. The contractor shall submit for the Contracting Officer's review and approval a complete test plan and test specifications covering all initial quality assurance tests required to demonstrate compliance with the requirements of this specification. The test plan shall outline all test devices, test facilities, methods, procedures, sequences, extent of test data to be obtained and methods of data presentation. Electronic test equipment to be used shall be identified by manufacturer and type. The contractor shall devise a test method for submission with the test plan for approval by the Contracting Officer's Technical Representative (COTR) where a test is required in Table 4-1 but where a test for the requirement is not defined herein.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection. The contractor shall be responsible for all inspection requirements as specified herein. Except as otherwise specified, the contractor may utilize his own or any other inspection facilities and services acceptable to the Government. Records of tests shall be kept complete and available for government review. The Government reserves the right to perform any of the inspections set forth in this purchase description where such inspections are deemed necessary to assure supplies and services conform to specified requirements.

4.1.1 Reviews. An informal review of applicable design parameters shall be made by contractor engineering personnel with the COTR to verify that the equipment final configuration meets the requirements specified in Table 4-1, to be verified by "Review".

4.1.1.2 Examinations. Examinations shall consist of a visual examination of the unit, subassembly, or component, by the contractor quality assurance inspector and/or the COTR to show compliance to the requirements specified in Table 4-1, to be verified by "Exam". An item shall be entered in the quality control history record for each equipment to be verified by examination.

4.1.1.3 System Tests. Acceptance tests shall be conducted by contractor test personnel and observed by the contractor quality assurance inspector or the COTR to show compliance to the requirements specified in Table 4-1 to be verified by "TEST". The results of the acceptance tests shall be entered in the contractors appropriate files and reported in the Acceptance Test report.

4.1.1.4 Demonstration. Demonstrations shall be conducted by contractor personnel and observed by contractor quality assurance, and/or a COTR designated representative to show compliance to the requirements specified in Table 4-1 to be verified by "DEMO".

TABLE 4-1

Quality Conformance

Requirement Paragraph	Requirement	Review	Exam	Test	Demo
3.2.1.1	Starting, normal operation and restarting				X
3.2.1.2	Cooling			X	
3.2.1.3	Illumination	X		X	
3.2.1.4	Total flux	X		X	
3.2.1.5	Azimuthal beamspread	X		X	
3.2.2.2	Weight		X		
3.2.2.3	Power switches				X
3.2.2.4	Indicator lamps				X
3.2.2.5	Elapsed time meters				X
3.2.3	Reliability	X			
3.2.4	Maintainability				X
3.2.5.1	Humidity			X	
3.2.5.2	Vibration			X	
3.2.5.3	Shock	X			
3.2.5.4	Sand and dust	X			
3.2.5.5	Rain	X			
3.2.5.6	Immersion			X	
3.2.5.7	Explosive atmosphere	X			
3.2.5.8	Temperature-altitude			X	
3.3.1	Materials, processes and parts	X			
3.3.1.2	Treatment and painting	X			

Requirement Paragraph	Requirement	Review	Exam	Test	Demo
3.3.2	Power	X			
3.3.2.1	Protection against AC phase reversal damage	X			
3.3.2.2	Wiring	X	X		
3.3.2.3	Cables and connectors	X	X		
3.3.2.4	Bonding and grounding	X	X		
3.3.2.5	Electrical overload Protection	X			
3.3.2.6	Undervoltage protection	X			
3.3.3	Hermetically sealed semi-conductors and integrated electronics	X	X		
3.3.4	Insulating and impregnating compounds	X			
3.3.5	Fungus, moisture resistance and salt fog	X			
3.3.6	Electromagnetic radiation			X	
3.3.7	Nameplates and product marking		X		
3.3.8	Workmanship		X		
3.3.9	Interchangeability	X			
3.3.10	Safety	X	X		
3.3.11	Human performance/human engineering	X	X		
3.4	Documentation	X			
3.5.1	Luminaires	X	X		
3.5.1.1	Lamp	X	X		
3.5.1.2	Lamp holder/socket assembly	X	X		
3.5.1.3	Reflector(s)	X	X		

Requirement Paragraph	Requirement	Review	Exam	Test	Demo
3.5.1.4	Housing	X	X		
3.5.1.5	Coverplate	X	X		
3.5.2	Mounting pods	X	X		
3.5.3	Power supply	X	X		
3.5.4	Electrical cables	X	X		

4.2 Inspection procedures. The following procedures and methods shall be used for the reviews, examinations, test and demonstrations specified in Table 4-1. Where procedures are not listed below, the contractor shall devise procedures to be submitted as part of the test plan for approval by the COTR. Basis for acceptance or rejection shall be conformance with the applicable requirement listed Section 3.

4.2.1 Starting, normal operation and restarting. The contractor shall devise a demonstration procedure acceptable to the COTR which incorporates the following steps:

a. With required power input, switch the power switches of the WAILS to the "on" position.

b. Measure time to ignite and reach 80 percent of full light output.

c. Operate WAILS continuously for a minimum of 1 hour.

d. Switch power off.

e. Switch power on again.

f. Measure time for reignition.

4.2.2 Cooling. The outer metal housing of a mounting pod/luminaires combination shall be instrumented with a pyrometer. The WAILS shall be ignited. Temperature of the housing shall be measured after 15 minutes of operation.

4.2.3 Illumination. The contractor shall devise a test acceptable to the COTR that will provide the far-field intensity distribution of the WAILS and show analytically what illumination distribution would be obtained on the water with the helicopter operating at an altitude of 500 feet, assuming atmospheric visibility of 8 kilometers.

4.2.4 Total flux. The contractor shall devise a method acceptable to the COTR for determining the total flux of the lamps of the WAILS and to show analytically what the useable flux from the WAILS is.

4.2.5 Azimuthal beamspread. The contractor shall devise a method acceptable to the COTR for determining the far-field azimuthal beamspread of the WAILS. The azimuthal beamspread shall be determined for every 15 degree increment from a direction perpendicular to the water as mounted on the helicopter to 75 degrees from the perpendicular.

4.2.6 Weight. The weight of the total WAILS shall be determined to within an accuracy of ±2 pounds.

4.2.7 Power switches. The contractor shall demonstrate in the presence of the COTR that the power switches operate the appropriate banks of luminaires as specified.

4.2.8 Indicator lamps. The contractor shall demonstrate in the presence of the COTR that the indicator lamps light when the appropriate luminaires are lit.

4.2.9 Elapsed time meters. The contractor shall demonstrate that the elapsed time meters function as specified for their respective banks of luminaires.

4.2.10 Reliability. The contractor shall provide engineering data sufficient to show that the MTBF of the WAILS should be at least 1000 hours.

4.2.11 Maintainability. The contractor shall demonstrate relamping of the WAILS luminaires and other maintenance operations by use of commonly available tools.

4.2.12 Humidity. Method 507, Procedure II of MIL-STD-810.

4.2.13 Vibration. Method 514, Procedure I, of MIL-STD-810.

4.2.14 Shock. The contractor shall provide engineering data sufficient to show that the WAILS will conform with the shock requirement.

4.2.15 Sand and dust. The contractor shall provide data to show that the WAILS will withstand the required sand and dust environment without damage.

4.2.16 Rain. The contractor shall provide data to show that the WAILS will withstand the required rain environment without damage.

4.2.17 Immersion. Method 512 of MIL-STD-10, immersion in salt water.

4.2.18 Explosive atmosphere. The contractor shall provide evidence that the WAILS will meet the explosive atmosphere requirement.

4.2.19 Temperature-altitude. Method 504, Procedure I of MIL-STD-810 for equipment Class 1A.

4.2.20 Materials, processes and parts. The contractor shall provide data sufficient to show that the WAILS design meets the materials, processes and parts requirements.

4.2.21 Power. The contractor shall provide evidence that the WAILS has been designed for the power required, has the required phase reversal protection, overload protection and undervoltage protection.

4.2.22 Circuitry. The circuitry shall be examined in the presence of the COTR and data shall be presented to show that the requirements for cables and connectors, bonding and grounding and hermetically sealed semiconductors and integrated electronics are met.

4.2.23 Treatment. The contractor shall present evidence to show that the requirements for insulating and impregnating compounds and fungus, moisture and salt fog treatment are met.

4.2.24 Electromagnetic interference. Testing of the WAILS shall be in accordance with MIL-STD-462, equipment Class 1D.

4.2.25 Nameplates and marking. The WAILS shall be examined in the presence of the COTR to determine conformance with the requirement.

4.2.26 Workmanship. The WAILS shall be examined in the presence of the COTR to determine conformance with the requirement.

4.2.27 Interchangeability. The contractor shall present evidence that parts of the WAILS are interchangeable in accordance with the requirement.

4.2.28 Safety and human factors. The WAILS shall be examined in the presence of the COTR and evidence shall be presented that the design meets the safety and human performance/human engineering requirements.

4.2.29 Documentation. Documentation shall be reviewed in the presence of the COTR to determine conformance with the requirement.

4.2.30 Major parts. All major parts and assemblies shall be examined in the presence of the COTR to determine conformance with the requirements of paragraph 3.5.

5. PREPARATION FOR DELIVERY

5.1 Packaging. The WAILS shall be packaged separately in accordance with best commercial practice to ensure safe delivery and to withstand normal handling and storage practices. Installation instructions shall be provided upon receipt of the system.

5.2 Marking. Each package shall be durably and legibly marked with

the following information in such a manner that the markings will not become damaged when the packages are opened.

Nomenclature
Contract Number
Manufacturer's name
Manufacturer's serial number
Assembly date

6. NOTES

6.1 Intended use. The WAILS is intended for use as an airborne lighting system for search and rescue operations at night.

6.2. Ordering data. Procurement documents should specify the following:

a. Title and date of this purchase description
b. Technical publications to be furnished
c. Any other special conditions

6.3 Definitions. Terms applicable to reliability, maintainability, human factors and safety shall be as defined in MIL-STD-721. Definitions of other terms are listed in the subparagraphs below.

6.3.1 Damage. Breakage, loosening, shifting; evidence of corrosion or failure of any finish, hardware, connection of component; leakage or condensation of moisture within the searchlight; any degradation in input or output characteristics; or failure to operate in accordance with the requirements of this specification.

6.3.2 "g". An acceleration or deceleration of the magniture 980.6 centimeters per second per second.

6.3.3 Azimuthal beam intensity distribution. A graph of beam intensity (in degrees) versus azimuthal angle (in degrees) measured in a plane through the axis of symmetry of the lamp.

6.3.4 Azimuthal beamspread. The included angle measured between the points at ten percent of the peak intensity on the azimuthal beam intensity distribution.

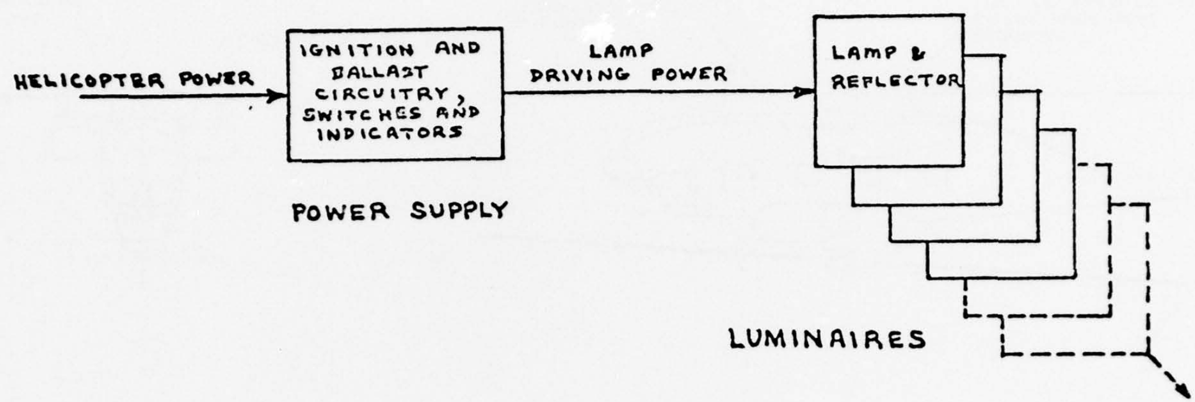


Figure B-1. WAILS Functional Block Diagram

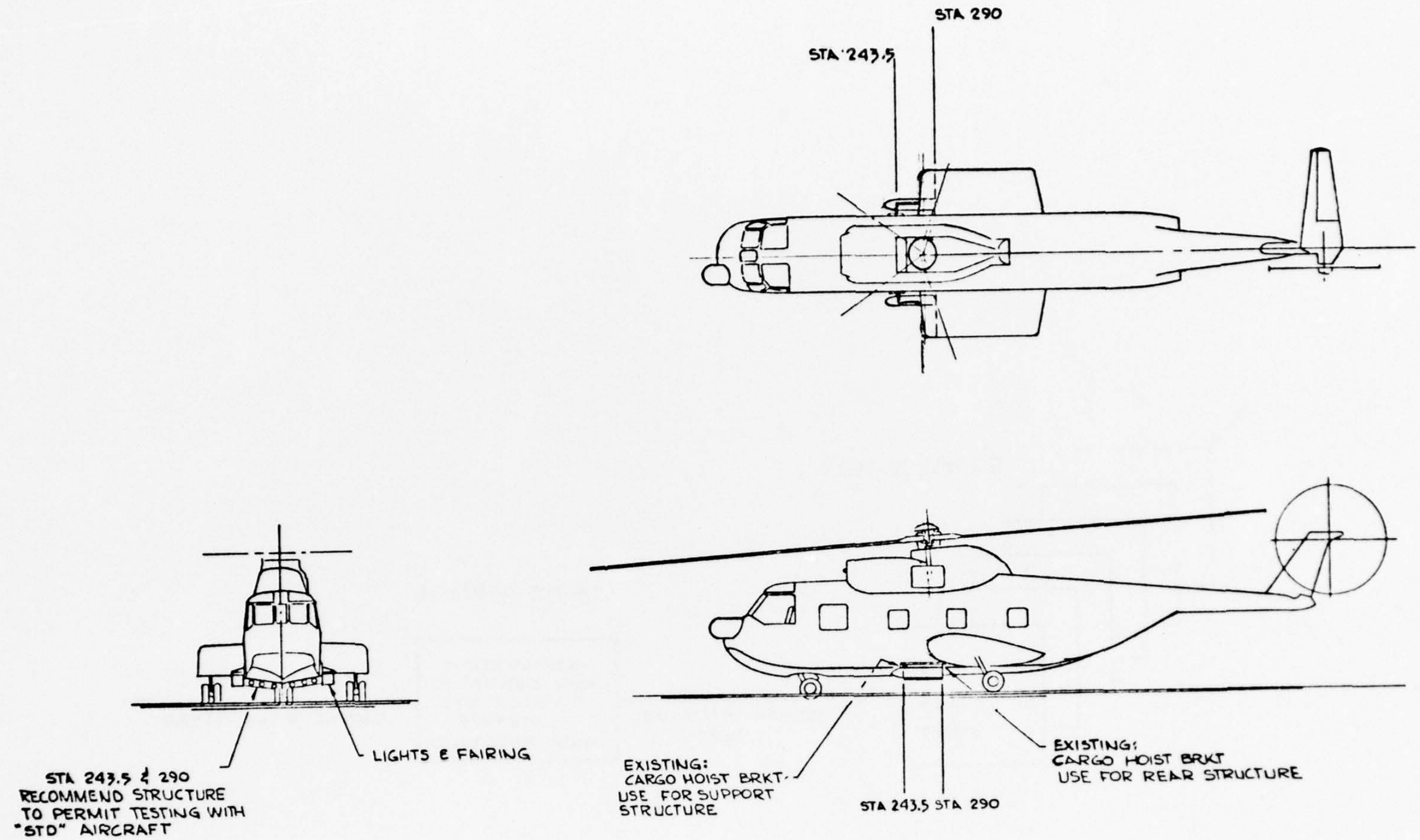


Figure B-2. Mounting Locations - Luminaires

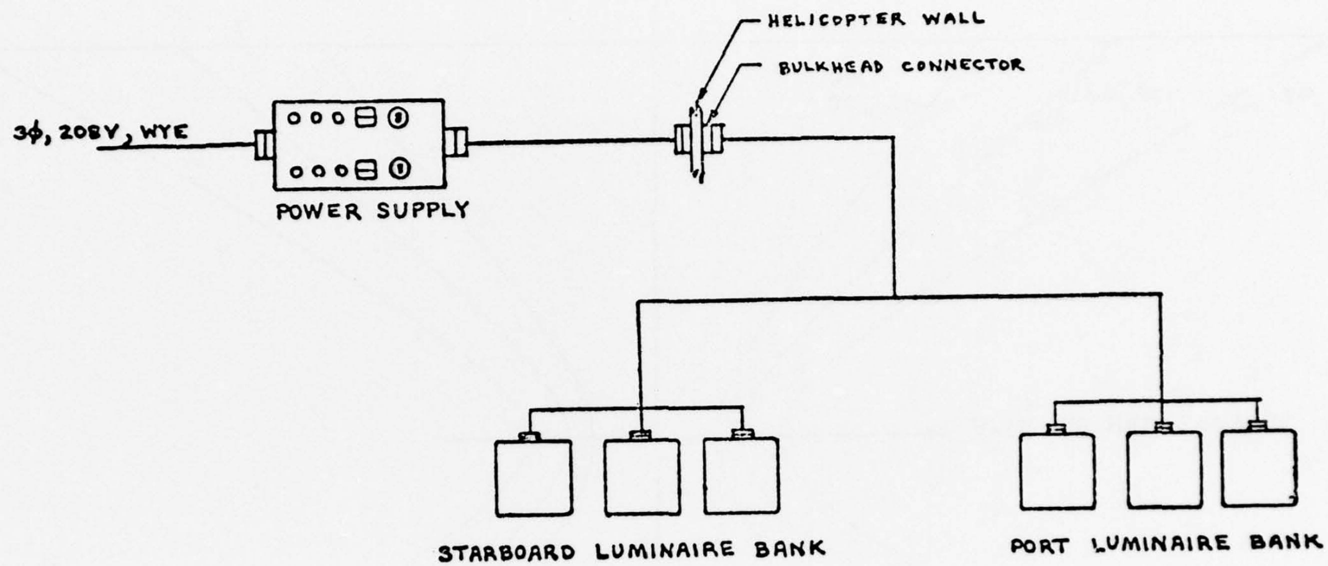


Figure B-3. WAILS Electrical Interconnection Diagram

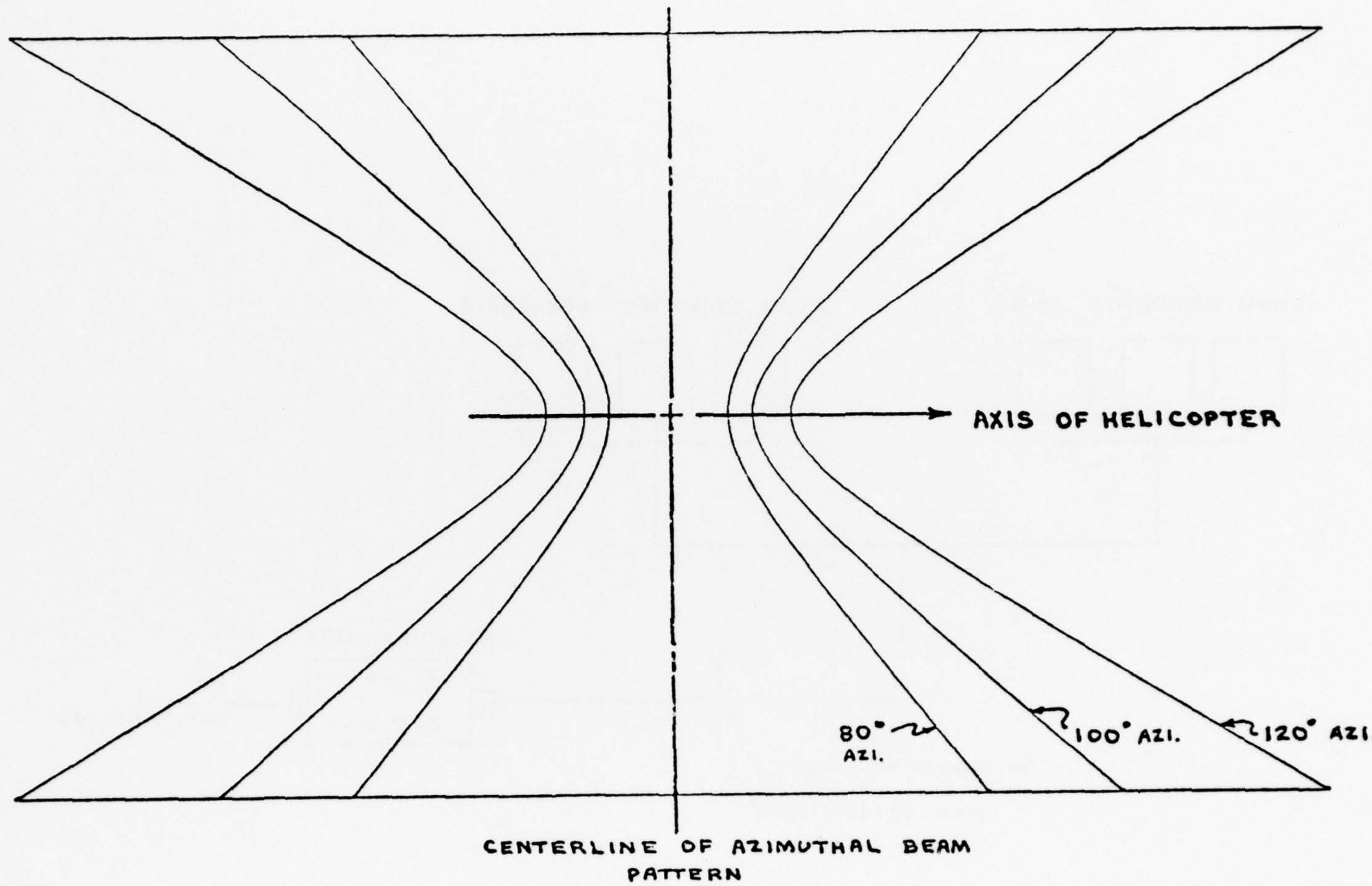


Figure B-4. WAILS Beam Pattern On Water

APPENDIX C

Illuminator Test Plan

Section I

1.0 Project Identification:

1.1 Subject: Wide Area Illumination System (WAILS)

1.2 Contract No.:

1.3 Type of Test: Operational Acceptance Test

1.4 Responsible Agency: Night Vision Laboratory, Fort Belvoir, VA.

1.5 Classification: UNCLASSIFIED

Section II

2.0 General:

2.1 Introduction: The WAILS is an illumination systems which will be installed and used on the Coast Guard HH-3F helicopter as shown in figure 2 of the purchase description.

2.2 Scope: Described herein is the Operational Acceptance Test Plan for the WAILS. This test program will be conducted at the Night Vision Laboratory (NVL) or facilities remote to NVL, but under the supervision and control of NVL personnel.

2.3 Objective: The purpose of this test is to complete inspection for Government acceptance, to determine operational utility of the WAILS and to identify any operational deficiencies which might require design changes in later models.

2.4 Description: The WAILS is a wide area illumination system mounted on the HH-3F helicopter to aid in search and rescue operations at night. This system consists of two banks of luminaires mounted as per the purchase description, plus a power supply and associated electrical cables.

Section III

3.0 Details of Tests:

3.1 General: This test will cover the operational testing to be performed by Government personnel on the WAILS after delivery and installation of

the system by the contractor on the HH-3F test aircraft. Acceptance testing to be performed by the contractor at his plant will be accomplished in accordance with the detailed test plan to be contractor generated and Government approved in accordance with the development contract. This test will cover four (4) areas, and will consist of Examination, Operational Checkout, Flight Checkout and Night Search and Resuce Simulation.

3.2 Failure Criteria: Failure is defined as breakage, loosening or shifting of any component, or the inability to meet any of the specifications set forth in the purchase description.

3.3 Test Report: A final report will be written at the conclusion of the test. Interim reports will not be submitted. Data on each test, however, will be available to authorized agencies upon request through proper channels.

3.4 Examination: The entire WAILS shall be examined in order to determine if damage has resulted from shipping or installation. To confirm that the WAILS installation is secure, safe for operation, and satisfactorily interfaced; and to determine if the system meets all requirements of the purchase description that can be performed by physical inspection.

3.5 Operational Checkout:

3.5.1 Ground Checks. With the aircraft on the ground and engines running, each bank of luminaires shall be turned on and checked for proper ignition and operation.

3.5.1.1 Starting and Restarting. With power on, ignite the lamps of the luminaires and measure the time to ignite and reach eighty (80) percent of full light output. Run the WAILS for a minimum of fifteen minutes. Switch power off and then immediately turn back on and measure time to reignition.

3.5.1.2 Cooling. The aircraft skin next to the luminaires and pods shall be instrumented with a pyrometer. The WAILS shall be ignited, and the change in skin temperature shall be measured after a minimum of 15 minutes of operation.

3.5.1.3 Input Power. With the WAILS turned on and the luminaires fired, measure the total KVA input power.

3.5.1.4 Electromagnetic Radiation. The aircraft radio, navigation and electronic equipment shall be checked to see that there is no interference during the operation of the WAILS.

3.6 Flight Checkout:

3.6.1 Aerodynamic Stability. Starting from hover and proceeding in steps to a minimum of 100 knots, the WAILS shall be checked for excessive vibration and any undesirable effects in the aircraft flight characteristics including excessive drag.

3.6.2. Electromagnetic Interference. Repeat procedure listed in 3.5.1.4.

3.6.3 Thermal Shock. The aircraft shall land in the water immediately after turning the power off to the luminaires in order to determine if the system can withstand the thermal and mechanical shock, and will remain water tight. This shall be done after operating the WAILS for at least 15 minutes. Downward velocity of the helicopter shall be no more than 500 feet per minute. Immediately after takeoff the WAILS system will be turned on and checked for proper operation.

3.6.4 Backscatter. During the testing program at night, there should be noted any backscatter by the WAILS that would interfere with the duties of the pilot, copilot or any crew member.

3.7 Night Search and Rescue Simulation Test. The target detection capability of the WAILS shall be determined through a series of runs under the following conditions using the normal Coast Guard search and rescue procedures and under the control of the NVL radar system.

Altitude:	500 feet
Velocity:	50, 75, 100 knots
Sea State:	Sea State 2 (Beaufort Scale), 4-6 Kts wind velocity with small wavelets and crest of waves of glossy appearance, not breaking
Visibility:	8 KM (5 miles) desired
Ambient Light Level:	Full moon, Half moon, No moon
Targets:	2 ea. 16-ft. white fiberglass boats, 2 ea. men in the water with orange life jackets
Observers:	Minimum of four
Runs:	Six runs for each condition for each observer, using two different aspects of the target (side view and front or back view).
Target Distance:	Random position from zero to 2640 feet (.5 miles) either side of the center line of the path of the helicopter. The length of the test range will be 5 miles.

3.7.1 Search Test. To determine the search effectiveness of the WAILS, targets will be positioned at a known distance from the observers and the aircraft will be vectored towards the targets. The radar will place and keep the aircraft on course from start to stop of the run. The NVL Radar Van will have a complete communication system and the test director will operate from this van. The targets will fall anywhere in a half mile zone on each side of the aircraft for a path distance of 5 miles. Since there will be only

two targets of each type, it would be difficult to position the target at random and keep changing the target over a five knot path. Therefore, the targets will be positioned in two general locations and the start and end points of the test range will be moved back and forth to give the effect of moving the targets along the range. This can only be accomplished because testing will be over water and not near any known land points that will give the observers a clue as to where the targets are. This test will be done under control of the radar system using a 30-inch plotting board. The targets will be presented in two orientations. The man target will be floating flat in the water or vertical in the water. The boat will show a side view or an end view. Tests will be performed using three different speeds of the aircraft and three types of moon. There will be six runs of each target under every condition for each of the four observers for a total of 462 runs. Two observers (one for each side of the aircraft) will be used with a different target grouping for each observer, thus cutting the number of runs in half. All testing will be at an altitude of 500 feet.

3.7.2 Illumination Data. Illumination level measurements falling on the target will be taken at the time of detection.

3.7.3 Inspection. The WAILS will, upon completing a night's testing schedule, be thoroughly checked and inspected for proper operation and for any evidence of damage or infiltration of water into the system. The elapse time meter reading will be taken and logged upon the end of each testing day.

3.8 Data Required:

a. KVA input to the lamps each night.

b. Light level on the target at detection.

c. Distance from observer to target at detection.

d. Aircraft speed.

e. Length of time for run.

f. Run number.

g. Type of moon.

h. Type and number of targets and aspect.

i. Visibility during test.

j. Observers name and position.

k. Sea State